Maths Welcome Pack: A multi-sensory introduction to mathematics for high school students

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Introduction and theoretical framework: Before the box

This poster is about the experience of an "on field" project started in 2014 with a group of 28 14-y.o. students attending to the first year (9th grade) of Liceo Scientifico and a 10cm cube cardboard box containing a collection of items that led to a two weeks journey through the focal points in the act of doing mathematics, which are the new entries of the high school approach to the subject, such as proofs, their necessity in mathematics and the related use of a proper symbolic language.

It has been conceived as a starter for the study of high school mathematics, but it also proved an effective strategy to boost students' learning motivation and long-term knowledge retention about the subject as a whole.

As Raymond Duval points out, "the goal of teaching mathematics, at primary and secondary level, is neither to train future mathematicians nor to give students tools, which can only possibly be useful to them many years later, but rather to contribute to the general development of their capacities of reasoning, analysis and visualization" (Duval, 2006, p. 105). Taking this perspective, I wanted to investigate the effectiveness of a multi-sensory approach, which is quite frequent for lower grades but isn't a common practice for secondary mathematics teaching and learning, through the means of Arzarello's *semiotic bundle* theory, widening the semiotic system horizon "to contain gestures, instruments, institutional and personal practices and, in general, extra-linguistic means of expression" (Arzarello, 2006).

The project had a double goal: from a research point of view, I aimed at focusing on the "cognitive functioning underlying the various mathematical processes" (Duval, 2006, p. 104) and exploring the efficacy of "a rich semiotic bundle with a variety of semiotic sets" (Arzarello, 2006) to foster students' understanding of some pivotal mathematical concepts. From a didactic point of view I wanted to verify that this approach, which took its strength from "a gradually growing and multimodal cognitive environment" (Arzarello, 2006) could help students in building up long lasting memories connected to the practice of mathematics through the act of giving "personal meanings to mathematical objects" (D'Amore, 2003, p. 19).

Methodology: Inside and Outside the box

The study explores how students answered to questions and problems prompted by the 12 items in the box, during the first two weeks of the school year (approximately 10 hours of teaching). Data has been collected by the teacher through classroom observation and assessment of the assigned homework.

The content of the box, described in detail in a multimedia presentation, varied from tactile objects like the piece of string which triggered the ice-breaker kinaesthetic activity **The Magic Knot** (Can you tie a knot in a string without letting go of the two ends?) to a paper cut with an extract from a 1742 letter from Christian Goldbach to Leonhard Euler which lead to the unveiling of **The Goldbach mystery (**What is the Goldbach conjecture? And why is it a conjecture and not a theorem?).

A good example to illustrate how the notion of semiotic bundle can be used to decode the activities of students solving a mathematical problem is **The mystery of the four triangles** (Can you build exactly 4 equilateral triangles using six toothpicks of equal length?). Searching for the answer to this problem students came up with the wrong construction seen in fig.1.

Figure 1

Discussing this solution, they brought into play an articulate semiotic bundle made up of:

- gesture: manipulating the toothpicks to build the solution
- speech: discussing why the construction in the figure is wrong
- written signs: drawing other possible solutions
- arithmetic representation: figuring out that the slanted toothpicks in Figure 1 weren't long enough to play as diagonals of the square
- geometric representation: figuring out that the triangles in Figure 1 couldn't be equilateral

Expanding the semiotic bundle from gesture to arithmetic representation, they became gradually aware that the construction couldn't be solved in two dimensional space and it eventually helped them to elaborate the correct solution.

Conclusions: Beyond the box

The described case shows how the use of a full range of different types of representation (verbal, gesture and iconic exemplification) has been a key point in the procedure of developing the meaning of the mathematical objects involved. In the following school years (14-15 and 15-16), this class group attested in two synergic ways how successful this opening experience has been: on one hand, they proved to remember vividly the content delivered through the box and on the other they become more metacognitively aware of the importance of creating a range of different representations in order to have access to a mathematical concept or problem.

References

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