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A new era of manipulatives: making your own resources with 3D printing and other technologies

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Introduction

Understanding three-dimensional representations on a two-dimensional representation system can be challenging. It mainly means to be able to understand around a virtual dimension additionally to the representation of two dimensions. With the advent of production technologies that can quickly generate three-dimensional objects, being able to construct in three dimensions is becoming a key skill. Especially, since 3D printers have become widely available due to declining costs. Being affordable by schools, a 3D printer can help teachers to explore mathematical concepts with their students by printing their own materials. Knill and Slavkovsky (2013) claim that while models in the real world do not help much to prove mathematics, they do very much help in understanding the results of mathematics. In this poster, we intend to share with the Mathematics Education community how teachers can use 3D printing examples to trigger students' internal needs to develop mathematical proofs. In other words, through the manipulation of models students could feel the necessity to prove their observations or conjectures from their interaction with 3D printing. We feel that often students are "forced" to prove theorems that they don't have internal connections, but in this case, if students ask themselves whether or not it is sufficient to use a particular case to generalize cases they could be motivated for proving.

These daily life demands can also trigger fruitful discussions to mathematical ideas, particularly in 3D environment. Due to that, we consider the importance of sharing new approaches among teachers and exchange perspectives in how these initiatives with upcoming technologies can contribute for mathematics teaching.

3D printer at schools

The use of manipulatives in the classroom has been advocated for a long time. In his work, Post (1981) brings perspectives from Lesh, Piaget, and Dienes, who emphasize the importance in applying concrete materials with students, especially the young ones. The increasing application of 3D printing in different areas led us to discuss possibilities for using it in education settings, as creating, adapting and printing such manipulatives. Lieban et al. (2018) discuss ideas, and describe activities that make use of 3D printing in the school context. Some of the objects explored were logical games. They were developed in GeoGebra and Tinkercad, and then printed in a 3D printer.

These two resources were chosen due to their intuitive interface for educational purposes, and friendly connections with 3D printers.

Besides enhancing modeling competencies, these approaches with 3D printing can be a good opportunity to promote a student-centered learning environment. Students increase their motivation when working on activities that they create themselves (Nussbaum, 2013). In addition, moving from playing to making games, teachers and students develop skills that go beyond mathematics, like communication, creativity, collaboration and critical-thinking, the 4C's for 21st century demands.

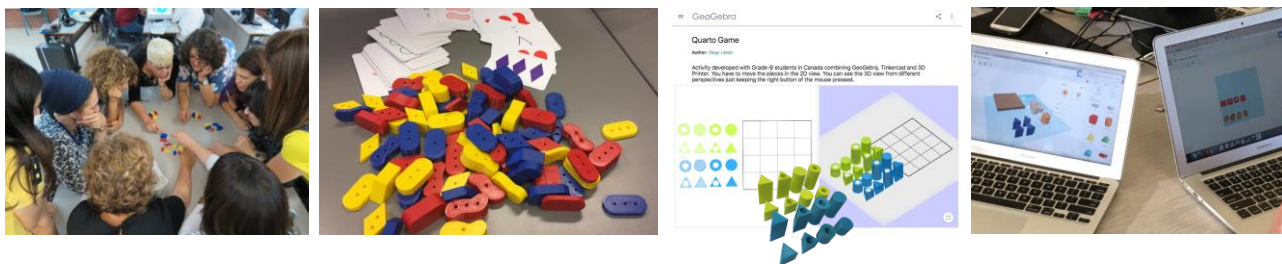


Figure 1: Game that already exists were adapted and explored by students and teachers

Perspectives in using 3D printing

The feedback from both experiences we had using 3D printing, which includes a school in Canada and a teacher-training program in Israel, opened our minds and booster our desire to explore further this powerful tool. We are now focusing in manipulatives that foster mathematical explorations, either to facilitate spatial reasoning or to open questions and discussions from them. Our first step in that direction is to evaluate a range of materials that are already available online in collaborative platforms (e.g. Thingiverse, GeoGebra, Tinkercad, ...), and from which users can easily download a printable file. We are collecting, adapting, and testing many of these materials and evaluating their perspectives for using them in different levels of education.

Proposal

The digital poster will present some perspectives in using 3D printing for mathematics teaching in different educational levels as well as how can these physical manipulatives be integrated with other digital tools. Some examples will be shown and explained, even as printouts in 3D.

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