

Math, modelling and art: One step to STEAM through physical and digital resources combined in a maker culture approach

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Introduction

In this study, high school students were assigned to develop puzzles based on their own drawings, made with GeoGebra (using circles and lines) as part of an Analytic Geometry task. Inspired by a technique utilized for logos, students had to work with inequalities and laser cutting machines to produce their puzzles. Based on the integration of prototype construction in mathematical modelling tasks discussed by Baioa and Carreira (2019), we sought to use real demands¹ to provide educational STEM (or STEAM) contexts. In this study, students have used their final works with geometric modelling (Lieban & Lavicza, 2017) to convert art in puzzles or games, which were distributed among other children in need for such educational materials.

In this study, the development of prototypes is used to evaluate potentials for innovations in educational technologies to address issues with the current and future usages of technologies, particularly combining GeoGebra and laser cutting in STEM Education. Here, interdisciplinary and transdisciplinary learning environments linking mathematic modelling more closely with other disciplines within the scope of STEM, and more recently, the inclusion of the Arts, (largely through designs and creativity) for develop the teaching of mathematics from STEM to STE-A-M transitions (Fenyvesi, 2016) came to the fore.

The focus of our work is on the emerging challenges when new technological environments are developed and evolve at a pace that exceeds the capacities of educational institutions. We argue that research methodologies need to be adapted to suit the rapid technological changes in society and education. In addition, the professional development of teachers needs to emphasize on the assisting of teachers to be able to keep up with the rapid changes in technology-related practices and pedagogies.

State of research

The effects of the balanced use of physical and virtual manipulatives (hands-on experimental tasks) have been considered in relation to the development of students' sense of credibility (Carreira & Baioa, 2018). In Brazil, the new National Common Curricular Base (BNCC, 2018) recommends working on project development (models / prototypes) to promote students' critical and creative thinking, involving them through their near and inherent contexts. In addition, the importance of alternative resources for different representation it also is highlighted, with special attention to the use of new technologies are highly valuable. While laser cutting technologies can enhance students' creativity, there is an extensive need for research to make these approaches more accessible for teachers, interesting for students as well as

¹The real demands come from public schools or and communities in need of pedagogical materials or educational games.

environmentally friendly. From a student-centred learning perspective, when digital natives interact with technologies in educational environments students tend to behave actively and not only consumers of information. Therefore, pedagogical interactions should be developed more through multiple access points, shared creations, research, among other particularities included in Information and Communication Technologies (ICT) and with the youth way of living in the 21st century (Bueno, Lieban & Ballejo, 2021). Figure 2 below provides examples of some of the students' productions and how these were explored by younger school children.



Figure 1: Based on logos' techniques (left), students developed their own puzzles (right)



Figure 2: From geometric modelling with GeoGebra to puzzles and games for younger school children

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