Exploring Meanings Around Inscribability Through Collaborative Programming and Modeling

Building a New Conceptual Field in a Community-Driven Context with MaLT2

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Abstract

The subject of this research is the study of students' collaboration on the debugging and production of digital models, within the programming environment MaLT2, to examine how collaboratively engaging with transformative technologies redefines learning, affects the production, expression and communication of ideas and how it enriches mental constructions and connections between abstract mathematical ideas and concrete programming implementations. This is an empirical study addressed to 9th grade students and consists of a series of exploratory activities assigning children the active role of 'co-creators' and creative tinkerers of digital artefacts, working in a community of practice with digital tools.

Keywords and Phrases: collaborative debugging, exploratory activities, textual programming, dynamic manipulation, DBR

1. Introduction

Digital environments, according to Papert (1980), are fields where, with appropriately designed activities, conditions fertile for rich experiences of meaning-making are ensured. "Microworlds" refer to rich computational environments that incorporate scientific concepts and their interrelationships, designed mainly to engage students in exploration and constructive hands-on activities (Healy & Kynigos, 2010). More specifically, "half-baked" microworlds are pedagogically engineered as flawed systems or "fallible artifacts" that contain built-in bugs (Kynigos, 2007) motivating users to explore, modify, and challenge the underlying rules and concepts. These microworlds are intended to serve as starting points for critical thinking and idea generation, as well as a resource for building or decomposing software by promoting malleability and offering deep structural access. Following this line of thinking, researcher's intention was to conceive digital projects and exploratory activities that integrate dynamic manipulation and modelling using a textual programming tool, to challenge children to collaborate to debug existing digital models and to produce their own personally meaningful artefacts (diSessa, 2001). For this purpose, the Conceptual Field "Inscribability" was assembled, intending to construct a network of related ideas (mainly drawn from Geometry and Trigonometry), representations

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and problem situations emphasizing the interconnectedness of mathematical concepts, arguing against the isolationist approach in education (Vergnaud, 2009). By posing the question whether -and under what conditions- a geometric entity can be inscribed in another, this study aims to investigate whether this arising Conceptual Field would be rich in opportunities for students to build interconnections and relate ideas drawn from various mathematical contexts. Utilizing Design-Based Research (DBR), the following research questions are being sought for answers:

1. What mathematical meanings do children construct within the Conceptual Field of Inscribability, while tinkering and dynamically manipulating digital models?
2. How can working in a community of practice with digital tools affect and deepen students' understanding and interconnecting of Euclidean properties?

2. Methodology

The learning environment MaLT2 (http://etl.ppp.uoa.gr/malt2/#Gr) integrates textual programming with the affordances of dynamic manipulation of parametric procedures, 3D graphics and camera navigation. This online Logo-like tool includes the following interrelated representations: i. Symbolic (code), ii. Figural and iii. Dynamic manipulation of generalized models controlled by procedures with variables (Kynigos & Grizioti, 2018).

This study was designed as a series of open exploratory activities addressed to 9^{th}-grade students (age 15-16) as a task of designing the interior space of a crazy ball and conducted with 26 students with little prior experience with MaLT2, over two sessions. The first phase required participants to identify and correct embedded mathematical errors in given procedures for inscribing models within a circle. In the second phase, each group selected a 2D object (e.g. letter, shape) to inscribe in both the circle and the sphere-crazy ball. The final phase extended to selecting and inscribing a 3D object within the sphere-crazy ball. Their work was documented via screen-recording software and video recordings, including audio and their digital artefacts (codes) were collected and analyzed.

3. Preliminary findings and discussion

Among the first findings of this study lay the meaningful use of mathematical formalism while modelling and programming. Dynamic manipulation of digital models influenced students' searching for relations and connections. Participants harmonically combined verbal and symbolic expressions to interact with the 2D and 3D figural representations, aiming to inscribe one in another. Some students decided on their own to use trigonometrical expressions to co-relate the radius of circle and the side of the inscribed triangle.

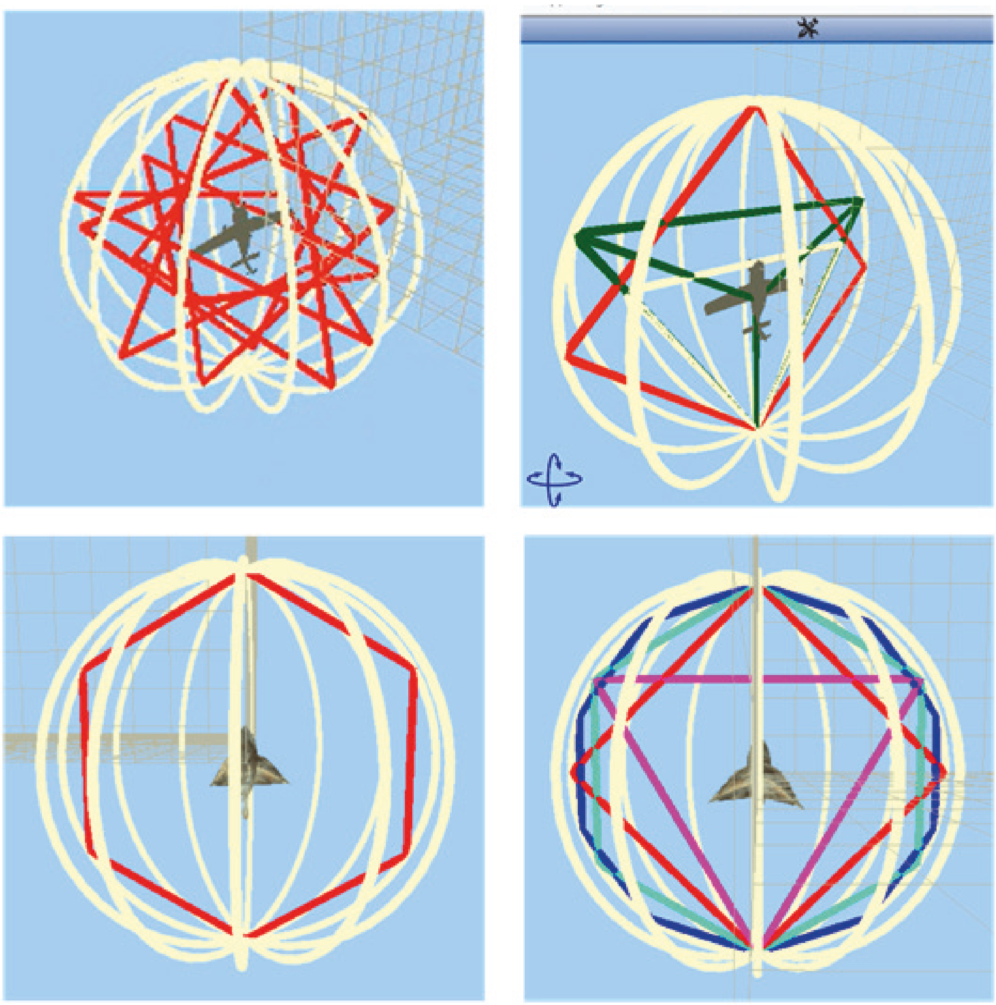

Figure 1: Students' artefacts.

Noteworthy results also include the variety of students' creative solutions to the problem. One group, after debugging the given procedure of a triangle, used it as a unit to base on and construct their own star-shaped model by rotation of the triangle. Another group generalized the debugged triangle procedure and created a regular hexagon and a regular decagon, inscribed in the same sphere. The social environment encouraged students to argue, justify their reasoning, and persuade peers, promoting active engagement and collective problem-solving. Group discussions were rich in questioning and clarification, enhancing the overall learning experience. Despite the limitation of the small number of participants, these first findings suggest that exploratory activities in this socio-technical environment provide rich opportunities for connecting mathematical concepts, foster creativity and promote collaborative problem-solving and critical thinking.

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