The Learning and Teaching of Calculus across Disciplines 2

- Pre-Conference Proceedings -

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MATH EXCELLENCE PROJECT

UNIVERSITÀ DEGLI STUDI DI MILANO
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A history-based artifact to mediate calculus contents

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A HISTORY-BASED ARTIFACT

This paper proposes incorporating history and historical artifacts into hands-on activities on infinitesimal calculus, aligning with Italian research on workshop activities involving "mathematical machines" (Bartolini Bussi & Maschietto, 2006). We have utilized a new device rooted in historical concepts related to the mechanical implementation of solutions for inverse tangent problems (Bos, 1988). Beyond their historical importance in the development of calculus, these ideas maintain a strong connection with material implementations, implying the creation of scientific instruments for demonstration, education, and practical application (Tournès, 2009).

Our artifact (Fig. 1), realized with FabLab tools (https://www.machines4math.com/), can be assembled in various configurations (Crippa & Milici, 2023): to introduce the concept of the tangent and inverse tangent problems (https://www.youtube.com/watch?v=LMLt90R8zHA), to trace exponential and parabola (https://www.youtube.com/watch?v=kqtU9GpcN78), and to construct derivatives and antiderivatives (https://www.youtube.com/watch?v=TyxCAR317HE).

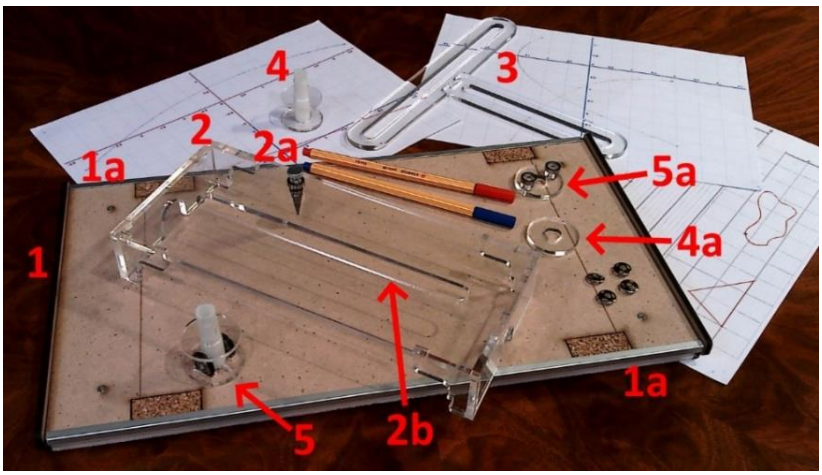

Figure 1. Components of the artifact.

THEORETICAL BACKGROUND

This study examines our new artifact from a semiotic perspective, emphasizing the crucial role of signs and representations in mathematics. The main theoretical component is the Theory of Semiotic Mediation (Bartolini Bussi & Mariotti, 2008); it applies a Vygotskian perspective to mathematics education, suggesting that teachers use specific artifacts to mediate mathematical meanings. A relevant theoretical tool is

the analysis of the semiotic potential of an artifact, which is crucial for designing student tasks and guiding teacher actions.

FIRST RESULTS AND FURTHER PERSPECTIVES

Our in-progress research project aims to evaluate our artifact for teaching calculus, focusing on its use, constraints, and manipulation to create effective tasks. We analyzed how a secondary school teacher explores this artifact from a semiotic perspective (Maschietto & Milici, 2024) and we identified different configurations and crucial elements for task design by analyzing its semiotic potential. In its most straightforward configuration, our artifact offers a material representation of the tangent line; in other configurations, the tangent is mechanically guided to generate curves.

We will start to test tasks to bring out the meanings embedded in the artifact. On the one hand, we plan to explore the artifact to consolidate mathematical meanings with university students. On the other hand, we are designing a teaching experiment to mediate calculus meanings; it will be carried out with high secondary school students. Additionally, the historical and epistemological aspects are essential for maintaining student interest: the artifact allows the integration of historical experiences and original manuscripts to enhance learning.

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REFERENCES

Bartolini Bussi, M.G., & Mariotti, M.A. (2008). Semiotic mediation in the mathematics classroom: artifacts and signs after a Vygotskian perspective. In L. English (Ed.), *Handbook of International Research in Mathematics Education* (2nd edition, pp. 746–783). Routledge. https://doi.org/10.4324/9780203930236

Bartolini Bussi, M.G. & Maschietto, M. (2006). *Macchine matematiche: dalla storia alla scuola*. Collana UMI Convergenze. Springer.

Bos, H. J. (1988). Tractional Motion and the Legitimation of Transcendental Curves. *Centaurus*, 31, 1,9–62. https://doi.org/10.1111/j.1600-0498.1988.tb00714.x

Crippa, D., & Milici, P. (2023) Transcendental curves by the inverse tangent problem: Historical and didactical insights for calculus, In: E. Barbin, R. Capone, et al. (Eds.) *History and Epistemology in Mathematics Education - Proc. of the 9th ESU* (pp. 181–193). Available at https://bibnum.publimath.fr/ACF/ACF23015.pdf

Maschietto, M., & Milici, P. (2024) Exploring a new geometric-mechanical artefact for Calculus, *Science & Education*. https://doi.org/10.1007/s11191-024-00547-7

Tournès, D. (2009). *La construction tractionnelle des équations différentielles*. Blanchard.