
MATHEMATICAL MODELLING AND SUSTAINABILITY: AN INTERDISCIPLINARY INTERVENTION FOR THE TRAINING OF FUTURE ENGINEERS

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ABSTRACT

This paper analyzes an interdisciplinary educational intervention based on problem-based learning (PBL) and integrated science, technology, engineering, and mathematics (STEM) methodology [1]. Implemented with engineering students at the Coimbra Institute of Engineering, the project evaluated the impact of addressing real-world territorial challenges on students' technical competence and intrinsic motivation [2, 3]. Working as energy consultants, students designed an integrated photovoltaic solar system for the Cunha Baixa region in Mangualde, Portugal.

The pedagogical workflow followed a quantitative, single-group, pre-experimental design (pre- and post-test) spanning five phases [2, 4]. Students engaged in peer-teaching activities by producing didactic audiovisual materials for secondary education, performed geospatial optimization, applied trigonometry for seasonal solar tilt tracking, and executed fundamental numerical calculation methods. Utilizing dynamic software tools like GeoGebra and Excel, they implemented optimization routines, Newton's fourth-order interpolation to predict climate production fluctuations, and the Bisection Method to establish the self-sufficiency break-even point against local urban demands.

Inferential statistical analysis ($n = 34$, $\alpha = .84$) confirmed a highly significant enhancement in students' technical skills and perceived self-efficacy ($t(33) = 11.56$, $p < .001$) with an exceptionally large effect size (Cohen's $d = 1.98$). The findings demonstrate that embedding abstract mathematical calculations, such as interpolation and numerical root-finding, within practical sustainability scenarios mitigates math anxiety, enhances conceptual assimilation, and builds professional social responsibility aligned with the UN 2030 Agenda.

Keywords STEM education · Mathematical modelling · Sustainable engineering · Problem-based learning · Numerical methods.

References

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