Outcome-Based Learning and Technology: An Innovative Model for Teaching Numerical Methods in Civil Engineering

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Abstract

This teaching innovation proposal is grounded in Outcome-Based Education (OBE), aiming to develop technical, digital, and collaborative competencies among civil engineering students. The model integrates Python and Google Colab as technological tools for the practical application of numerical methods, connecting mathematical theory with computational simulation and teamwork. The course is organized into ten thematic units, covering polynomial interpolation, nonlinear equation solving, numerical integration, and the solution of ordinary differential equations. Each unit aligns measurable learning outcomes with active learning strategies and performance-based evaluations. Artificial intelligence supports code development, analysis, and debugging, promoting critical thinking and technical autonomy. Through laboratory sessions, collaborative projects, and a final academic colloquium, students apply numerical methods to real-world engineering problems related to transportation, energy, and structural analysis. This approach strengthens their communication, problem-solving, and decision-making skills while encouraging the practical transfer of mathematical knowledge to engineering contexts. The proposed model fosters interdisciplinary learning, enhancing students' ability to collaborate in diverse fields and tackle complex challenges. The results demonstrate that active, technology-mediated, and outcome-oriented learning enhances conceptual understanding, retention, and professional competence. Consequently, this model offers a replicable and adaptable framework for teaching applied sciences in engineering, meeting current educational demands for digital tools, innovation, and interdisciplinary education.

Keywords: Active Learning; Artificial Intelligence; Civil Engineering; Outcome-Based Education; Python