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DEVELOPING AN APPLICATION-ORIENTED TEACHING MODEL FOR ADVANCED MATHEMATICS THROUGH DETERMINANT METHODS IN STRUCTURAL MECHANICS AND GEODESY

Abstract

Linear Algebra, particularly the concept of matrix determinants, is often perceived by engineering undergraduates as highly abstract and detached from industry applications due to traditional, calculation-heavy pedagogical approaches. This paper introduces an interdisciplinary, application-oriented teaching model designed to bridge the gap between Advanced Mathematics, Structural Mechanics, and Geodesy. By restructuring the "Matrix Determinant" module around a four-phase modeling process, the framework contextualizes mathematical theory through two structural extremes: a dynamic system analyzing structural resonance (dynamic criticality) and a static spatial system executing Gauss-Shoelace area calculations (geometric accumulation). By shifting the classroom focus from manual calculation to algorithmic processing via computational software, the model unifies distinct engineering fields under a single mathematical entity. The implementation outcomes demonstrate that this framework significantly enhances students' mathematical modeling capacities, fosters algorithmic thinking, and improves professional motivation among engineering undergraduates.

Keywords:

application-oriented teaching, matrix determinant, algorithmic thinking, dynamic resonance, gauss-shoelace formula, engineering mathematics.

1. Introduction

Traditional undergraduate engineering mathematics often emphasizes abstract algebraic manipulations and low-dimensional manual computations (2×2 or 3×3 matrices). This purely academic approach isolates foundational concepts from practical engineering, diminishing learning motivation and limiting students' mathematical modeling capabilities.

To bridge this theory-practice gap, this study proposes an innovative, application-oriented teaching model for the "Matrix Determinant" topic. Grounded in competency-based and contextual learning, the model integrates core mathematical concepts into two pillar engineering fields: Structural Mechanics (dynamic eigenfrequency analysis) and Geodesy (static spatial boundary evaluations). By converting the determinant from a static operation into an analytical diagnostic tool, the framework redefines how engineering students perceive and utilize Advanced Mathematics in their specialized fields

1 Theoretical Framework and Methodology

1.1 Theoretical Framework

The proposed model is rooted in Contextual Learning and Realistic Mathematics Education (RME). The instructional delivery follows a structured, four-phase modeling process to transition cognitive structures from physical phenomena to mathematical abstraction:

- **Phase 1: Engineering Problem Posing (Input):** Introducing an authentic professional dilemma (e.g., structural resonance or boundary tracking) to establish a clear technical need for analytical tools.

- **Phase 2: Mathematical Modeling:** Abstracting physical parameters (stiffness, mass, coordinate sets) into formalized linear systems or geometric arrays.

- **Phase 3: Algorithmic Processing:** Deploying the matrix determinant as the computational core, utilizing modern software (MATLAB, Excel) to shift the focus from manual calculation to conceptual execution.

- **Phase 4: Engineering Interpretation (Output):** Mapping the mathematical scalars back onto the physical domain to assess structural safety or survey precision.