

Methodology

Self-Study (LaBosky, 2004)

Exploring AI for use in task design

what is the matlab command for differentiating a function?

In MATLAB, you can differentiate a function using the `diff` function or symbolic computation with the **Symbolic Math Toolbox**. Here's how you can do it:

1. Using the `diff` function with symbolic math:

To compute the derivative symbolically, use the `diff` function with a symbolic expression or symbolic function.

```
matlab
syms x
f = x^3 + 2*x^2 + x; % Define the function
df = diff(f, x); % Differentiate f with respect to x
disp(df);
```

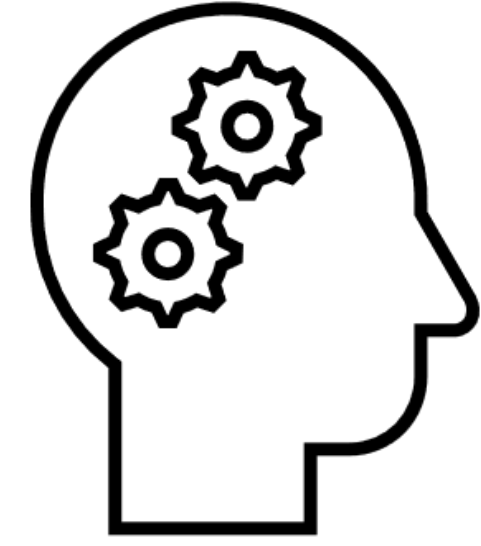
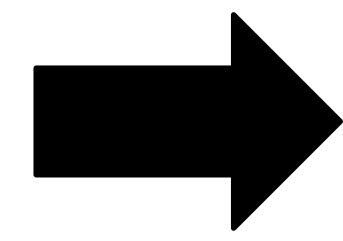
Output:

```
3*x^2 + 4*x + 1
```

2. Specifying the Order of Differentiation:

You can specify the order of differentiation by adding a second argument to `diff`.

```
matlab
syms x
f = x^3 + 2*x^2 + x;
df2 = diff(f, x, 2); % Second derivative
disp(df2);
```



Analysis

SVD Decomposition and Applications

Yes, please. When we talked about maximizing $|Av|^2$, A is a matrix, a vector, a number, and then how does that relate to maximizing the information?

When we talk about maximizing $|Av|^2$, A is a matrix, typically an $m \times n$ matrix representing the data or system we're analyzing. The vector v is an n -dimensional vector that we are looking to optimize. The goal is to find a vector v that maximizes the quantity $|Av|^2$, which represents the length of the projection of the matrix A onto the vector v .

Breaking it down:

- Matrix A :** This is the input matrix, typically a data matrix, where each row corresponds to a data point, and each column corresponds to a feature or dimension of the data. It has dimensions $m \times n$.
- Vector v :** This is a unit vector (meaning it has a length of one, $|v| = 1$) in the n -dimensional space. We're searching for the vector v that maximizes the projection of A onto this vector. The vector v corresponds to the "direction" in the feature space along which we are maximizing the variance or energy of A .
- Maximization of $|Av|^2$:** When we compute Av , we're effectively projecting the matrix A onto the vector v . This gives us a new vector in m -dimensional space (because A is $m \times n$). The squared length of this projection, $|Av|^2$, tells us how much of the "energy" or information of A is captured by projecting it onto v .
- Singular Value:** The value $|Av|^2$ is maximized when v is the first singular vector of A . The corresponding singular value σ_1 tells us how much "information" (or variance) is captured along that direction. In essence, σ_1 is the largest singular value of A , and v_1 is the direction that captures the most variance.

AI Conversations

Designing for Calculus integrated with Matlab

In MATLAB, you can perform **u-substitution** (or any variable substitution) using the **Symbolic Math Toolbox** with the `subs` function. Here's how you can do it step by step:

Basic u-Substitution Example

Let's say you want to integrate:

$$\int \sin(x^2) \cdot 2x \, dx$$

Using the substitution $u = x^2$, so that $du = 2x \, dx$.

MATLAB Code:

```
matlab
syms x u
f = sin(x^2) * 2*x; % Original function
% Define the substitution u = x^2
u_sub = x^2;
% Substitute x^2 with u
f_u = subs(f, x^2, u);
disp('Expression after substitution:');
disp(f_u);
```

Exploring Metaphors for Lie Groups

1. The Smooth Transformation Playground

Metaphor: Imagine a playground filled with different shapes—circles, squares, triangles—that can smoothly transform into one another without any tearing or gluing. You can stretch, rotate, or shrink these shapes in a continuous manner. The set of all possible transformations forms a smooth landscape where each movement follows specific rules.

- Explanation:**
- Manifold Aspect:** The playground represents a smooth manifold where each point corresponds to a specific shape or configuration.
 - Group Aspect:** The transformations (stretching, rotating) are the group operations. Combining two transformations is like performing one after the other.
 - Lie Group Connection:** The smoothness of the transformations ensures that the group operations are differentiable, embodying the essence of a Lie group.

2. The Infinite-Dimensional Orchestra

Metaphor: Consider an orchestra where each musician can adjust their instrument's pitch, volume, and timbre continuously. The entire orchestra can perform an infinite variety of sounds by smoothly altering these parameters. The combination of all possible sounds creates a rich, continuous sonic landscape.

- Explanation:**
- Manifold Aspect:** The space of all possible sounds forms a smooth manifold.
 - Group Aspect:** The musicians' adjustments are like group operations—combining changes in pitch and volume corresponds to combining group elements.
 - Lie Group Connection:** The continuous adjustments and combinations reflect smooth group operations, characteristic of Lie groups.

Fractions with Pre-service Teachers

Can you change the task so that it scaffolds learning about multiplying fractions first starting with a fraction times a whole number and culminating in a fraction a times a fraction?

Absolutely! Let's adjust the sequence of the "Layered Landscape" activity to scaffold learning about multiplying fractions, starting with multiplying a fraction by a whole number and culminating in multiplying a fraction by a fraction. This progression will help build students' understanding and confidence.

Task 1: Starting Simple - Fraction of a Whole

Objective: Students will calculate the fraction of a whole number to determine the size of single elements in their garden.

Materials:

- Construction paper in various colors
- Pencils and erasers
- Rulers for measuring

Instructions:

- Choose a Feature:** Each student chooses one primary feature for their garden, such as a meadow or a large tree area, represented as the "whole" garden.
- Calculate Fractional Parts:** Students decide what fraction of their garden will be occupied by the feature. For example, they might decide that trees will occupy $\frac{1}{3}$ of the garden.
- Introduce Whole Numbers:** Let the total number of trees planned be a whole number, say 12. Students calculate $\frac{1}{3} \times 12$ to find out how many trees they will actually plant, practicing multiplying a fraction by a whole number.
- Sketch the Plan:** Draw the layout on paper, showing the fraction of the garden each tree occupies.



Designing with ChatGPT: A Critical Conversation

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Emerging Themes

Main Idea	Detailed Description
Exploratory Use of AI for Linear Algebra Curriculum	Researchers discuss using AI (ChatGPT) to probe core linear algebra topics—such as singular value decomposition, matrix factorizations, and alternating least squares—to generate code examples and identify applications that fit an applied linear algebra course.
Integration of AI-Generated Code in Educational Task Design	The conversation shows how AI is used to generate code skeletons in languages like Python and MATLAB that illustrate mathematical procedures (e.g., least squares, SVD). These code examples serve as starting points that teachers can adapt, allowing students to focus on both the mathematics and coding aspects of the tasks.
AI-Enhanced Task Generation and Aesthetics	Both researchers explore using ChatGPT to create and modify math tasks with engaging contexts (e.g., landscaping, designing a monument) so that the problems are both mathematically rich and contextually relevant. They discuss how AI can alter the aesthetics while preserving the core content.
Reflection on Teacher Expertise in AI-Generated Materials	The dialogue reflects on how teachers' own knowledge and experiences are crucial for evaluating and refining AI-generated tasks. They emphasize the need for external guardrails (such as cross-checking with reputable sources) to ensure that the pedagogical value remains high.
Usability and Challenges of AI Voice Interaction in Math Education	The researchers discuss the benefits of using voice chat with AI for interactive exploration but also note challenges. In particular, the voice interface sometimes struggles with reading complex mathematical code and expressions, especially when background noise interferes.
Development of Supplementary Materials for Mathematics Instruction	There is discussion about transforming AI-generated outputs into tangible classroom resources. For example, one researcher worked on creating printable grid worksheets (e.g., for fraction multiplication) to support hands-on learning, despite the challenges of formatting and design.

Conversations, Poster, Paper, and More



Pre-Design with AI

- Exploring Mathematical Topics
- Generating Conceptual Metaphors and useful contexts
- Exploring and summarizing Math Education Research

Content Evaluation

- Critically evaluating generated content by comparing with seminal works and professional expertise.
- Identifying appropriate Mathematical Entry Points
- Finding conceptual metaphors and useful contexts to engage students

Final Refinement

- Editing to supplement or better illustrate the mathematical content not optimized by AI.

Formatting with AI

- Using AI to convert a task to LaTeX or code examples for an online workbook.

Design Process

