# Leveraging Generative AI for Teaching and Learning

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## Welcome!

> **Note**
>
> Please take a moment to consider:
>
> 1. What course would you most like to integrate AI tools into?
> 2. What's your biggest concern about using AI in your teaching?

**Workshop Goals:**

- Identify dimensions of AI integration in engineering education
- Analyze case studies using a structured framework
- Select appropriate AI approaches for your specific courses
- Begin developing an implementation plan
- Access resources for continued development

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## Workshop Schedule

- **Part 1: Foundation**
  - Introduction and AI landscape
  - The AI Integration Taxonomy
- **Part 2: Exploring the Taxonomy**
  - Dimensions of AI integration
  - Case examples across engineering disciplines
  - Discussion of implementation approaches

- **Part 3: Application & Planning**
  - Case study analysis in small groups (possibly)
  - Individual implementation planning (the main focus)
  - Next steps and resources

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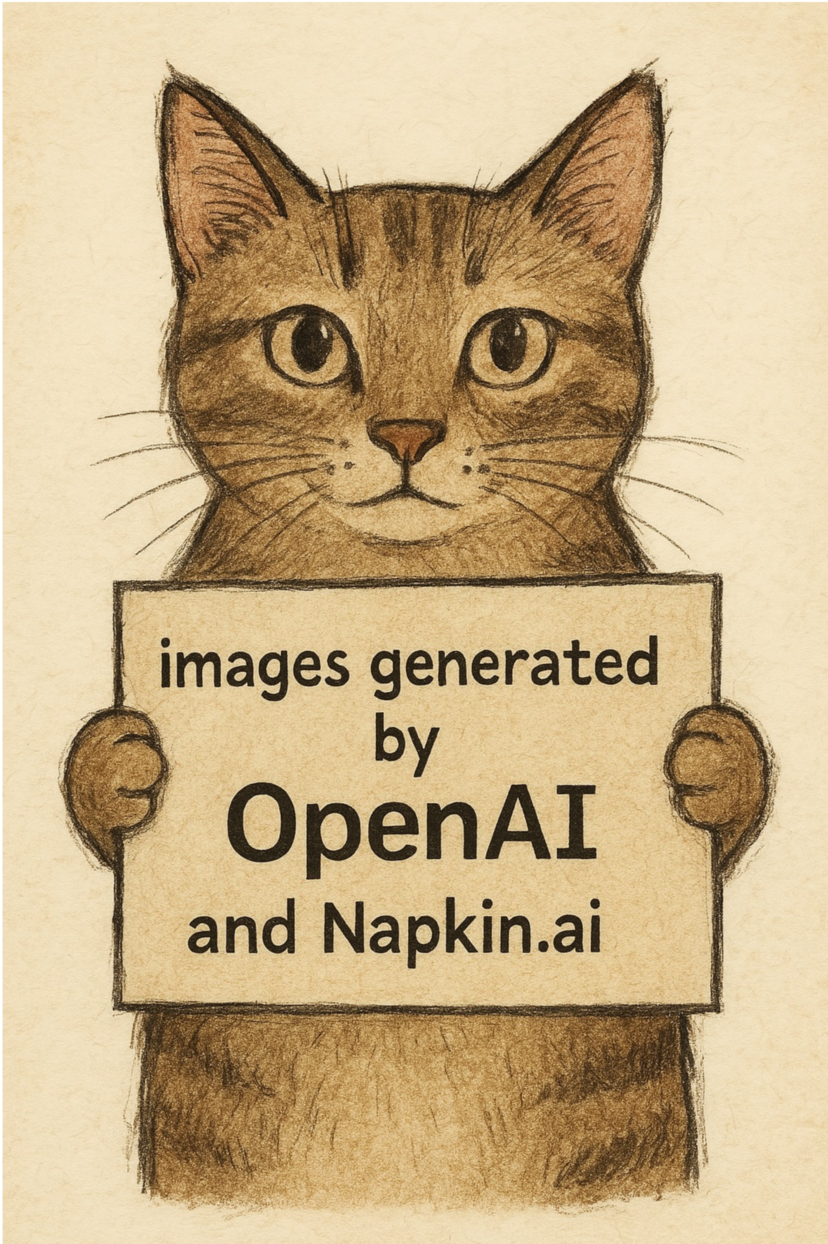
## Warmup and a Disclaimer

- Please "raise your hand" in Zoom
- Type something in the Zoom chat (e.g., "Hello", what department are you from, which course(s) are you teaching, etc.)
- The materials for this workshop are available at ideeaslab.com/resources/teaching
- This workshop is made with input from Claude-3.7 Sonnet and AI-generated images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## Foundation

### The AI Landscape in Engineering Education


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### The AI Landscape in Engineering Education


#### Generative AI Tools in Engineering

- Large Language Models (ChatGPT, Claude, Gemini, Llama-3)
- Code Generation (GitHub Copilot, Cursor)
- Image Generation (DALL-E, Midjourney)
- Speech Recognition (Whisper)
- Multimodal Tools (GPT-4o)

### Engineering Education Challenges

- Technical domain knowledge
- Visualization of complex concepts
- Skill development vs. conceptual understanding
- Balancing theory and application
- Preparing for evolving professional practice

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## Why a Framework for Integration?

### Ad hoc integration leads to:

- Inconsistent student experiences
- Missed pedagogical opportunities
- Assessment misalignment
- Potential equity issues
- Unclear expectations

### A structured framework provides:

- Common language for discussing integration
- Multiple dimensions for consideration
- Intentional decision-making
- Alignment with educational goals
- Disciplinary adaptability

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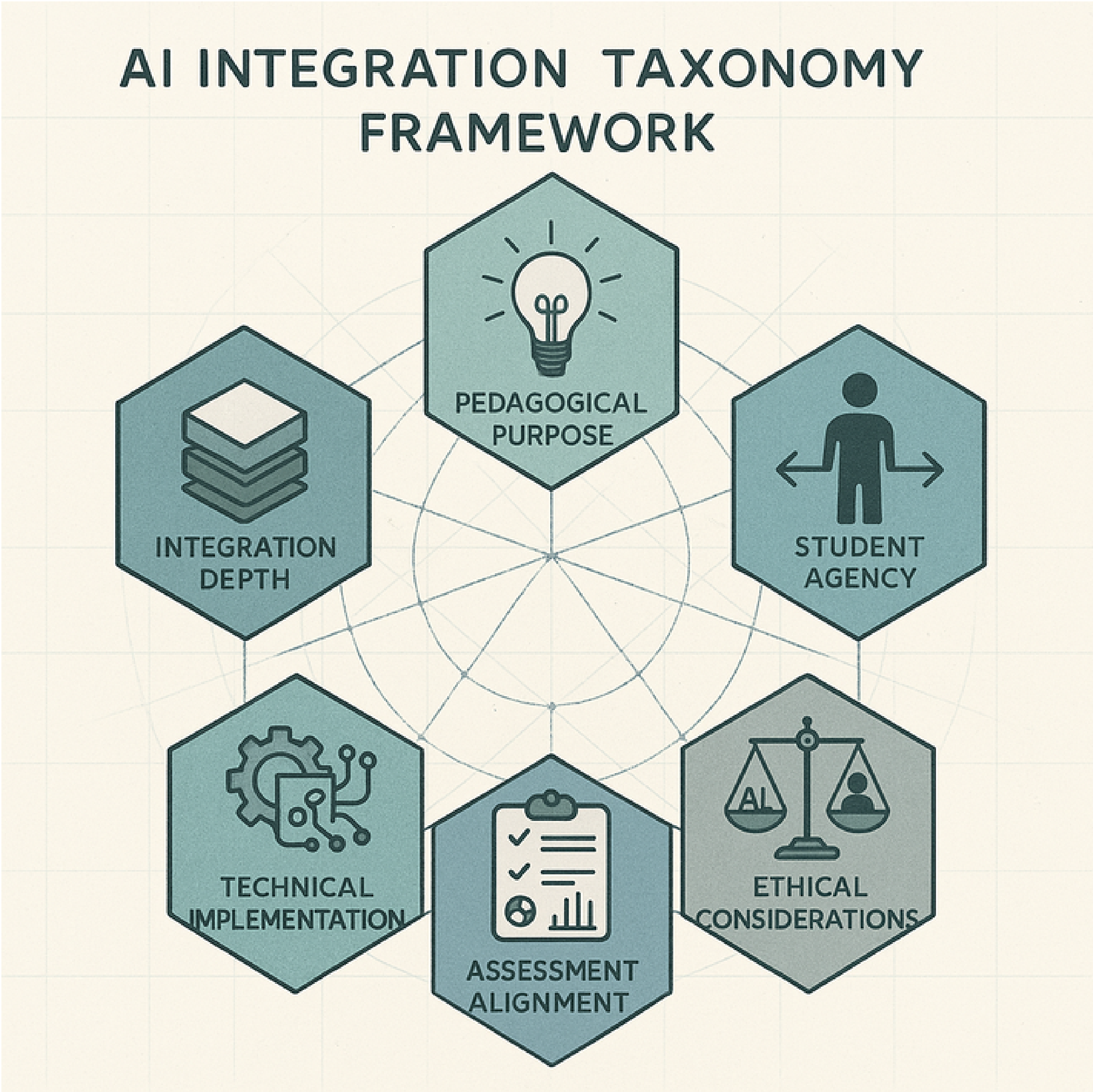
## The AI Integration Taxonomy

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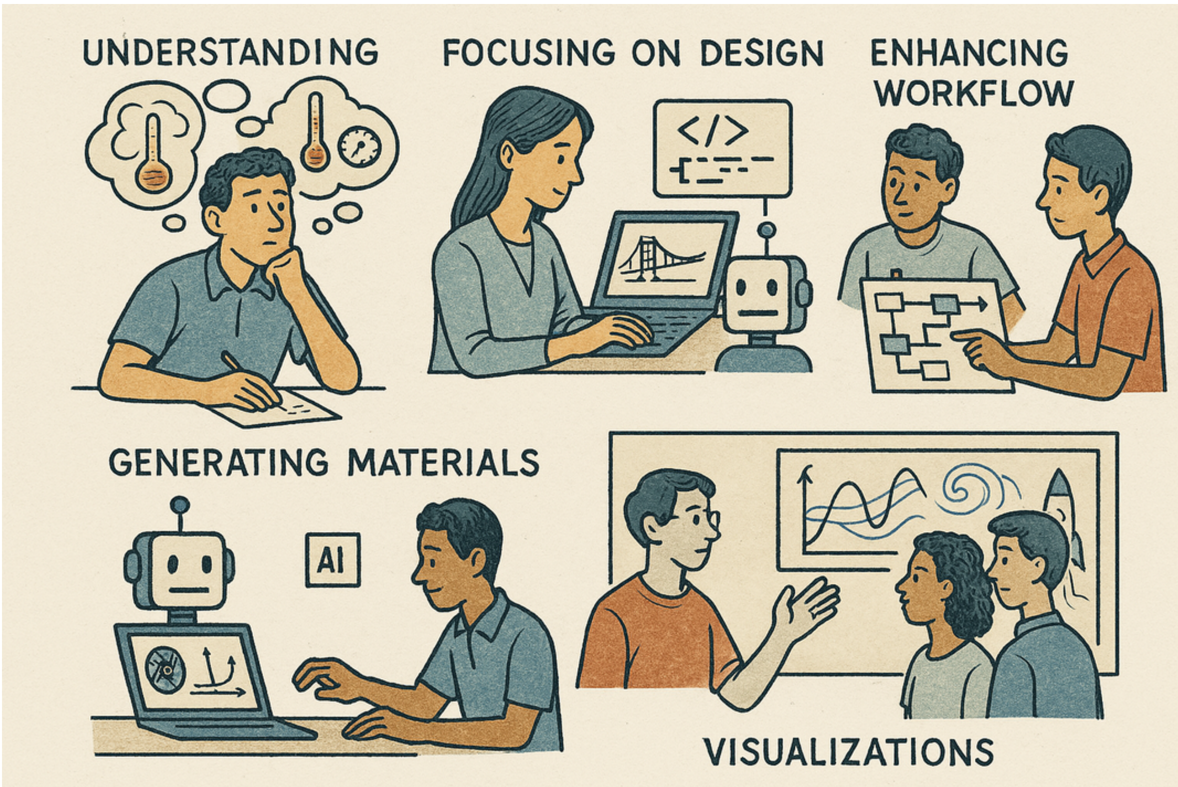
## The AI Integration Taxonomy

**Six dimensions to consider:**

1. **Pedagogical Purpose**
   *Why integrate AI?*
2. **Integration Depth**
   *How deeply embedded?*
3. **Student Agency**
   *How much student control?*
4. **Assessment Alignment**
   *How to evaluate learning?*
5. **Technical Implementation**
   *What technical aspects matter?*
6. **Ethical & Professional**
   *What broader implications?*

## Exploring the Taxonomy

### 1. Pedagogical Purpose Dimension

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### 1. Pedagogical Purpose Dimension

**Five primary purposes:**

- **Conceptual Understanding**
  *Explaining complex concepts, addressing misconceptions*
- **Skill Development**
  *Bypassing technical hurdles for higher-order skills*
- **Process Augmentation**
  *Enhancing workflows and methodologies*

- **Content Creation**
  *Generating or transforming educational materials*
- **Visualization**
  *Helping visualize complex phenomena*

**Engineering Example:**

In thermodynamics, students use ChatGPT to:

- Generate multiple explanations of entropy concepts
- Connect microscopic and macroscopic views
- Create conceptual comparisons between similar processes
- Identify and address common misconceptions

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## Purpose Dimension

> ℹ Note
>
> **Reflect on the following:**
>
> 1. What aspects of your courses are most challenging for students to understand?
> 2. Which pedagogical purpose seems most valuable for your context?
> 3. How might AI tools address these specific challenges?

**Consider:**

- Conceptually difficult topics
- Areas where students struggle with visualization
- Skills that require significant practice
- Content that needs multiple perspectives

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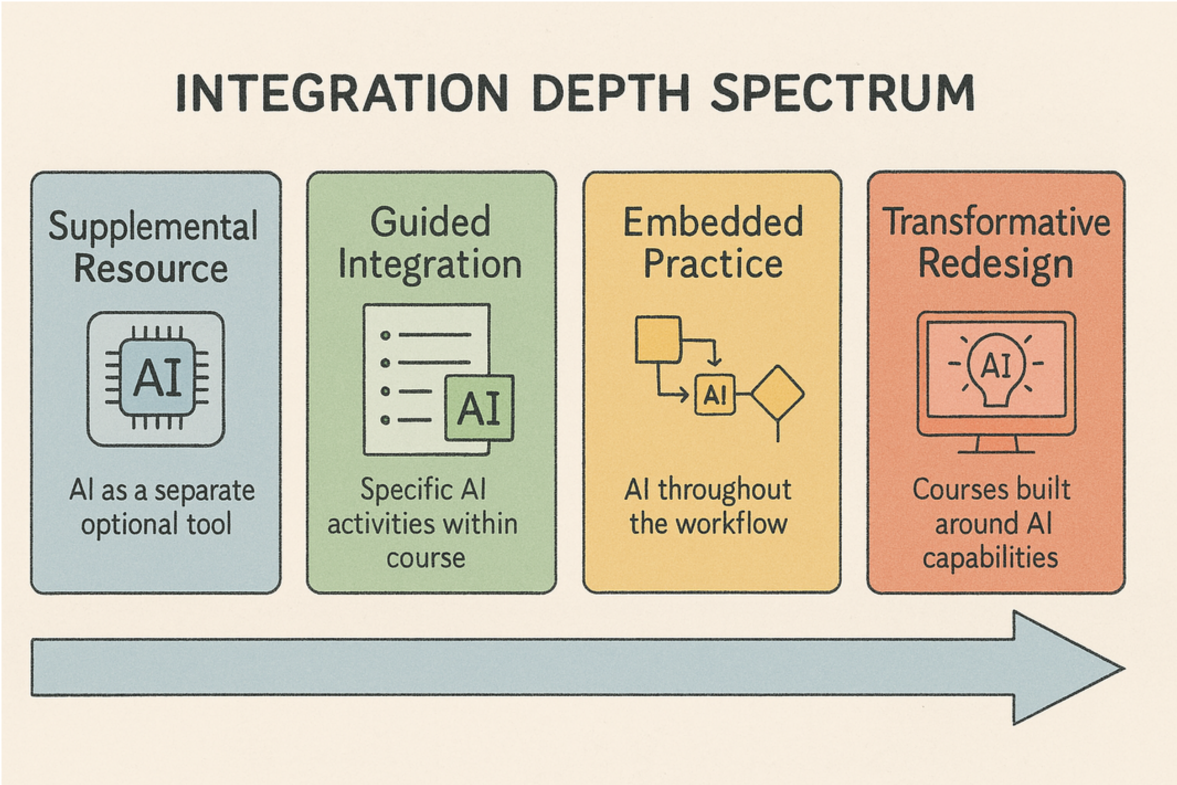
### 2. Integration Depth Dimension

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### 2. Integration Depth Dimension

**Spectrum of integration:**

- **Supplemental Resource**
  *Optional tools outside core instruction*
- **Guided Integration**
  *Structured prompts for specific activities*
- **Embedded Practice**
  *AI integrated throughout regular coursework*
- **Transformative Redesign**
  *Course restructured around AI capabilities*

**Engineering Example:**

In data structures course with GitHub Copilot:

- Started as supplement for debugging
- Moved to guided exercises comparing manual and AI-assisted implementation
- Evolved to embedded practice with design-first approach
- Assessment redesigned to focus on algorithm design over syntax

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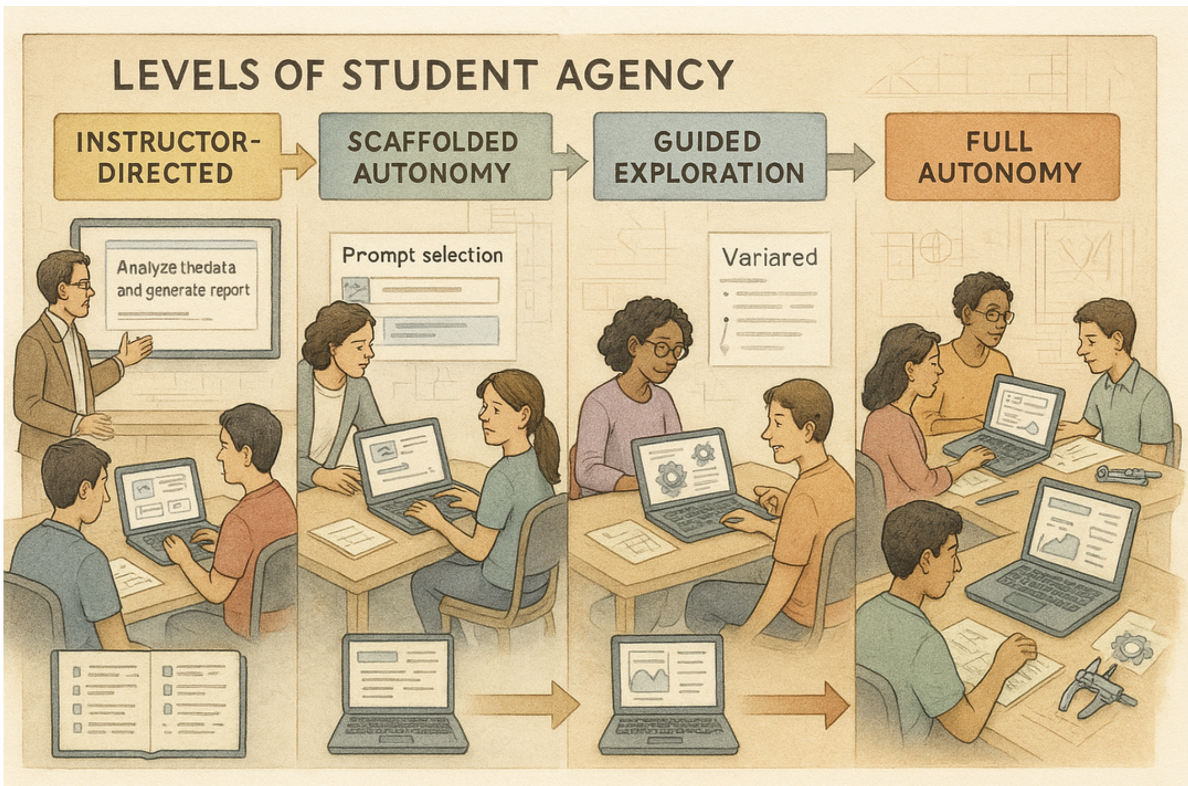
## 3. Student Agency Dimension

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### 3. Student Agency Dimension

**Levels of student choice and responsibility:**

- **Instructor-Directed**
  *Faculty provides specific prompts/tools*
- **Scaffolded Autonomy**
  *Progressive responsibility with guidance*
- **Guided Exploration**
  *Students experiment within boundaries*
- **Full Autonomy**
  *Independent decisions about AI use*

**Engineering Example:**

In a materials science course:

- Began with specific instructor-provided prompts
- Gradually introduced template libraries students could modify
- Moved to student-created prompts with guidance
- Culminated in students determining when/how to use AI tools

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## Integration & Agency

> Note
>
> **Reflect on the following:**
>
> 1. Current integration depth in your courses
> 2. Desired integration depth you'd like to achieve
> 3. Student agency level you'd be comfortable with

**Questions to consider:**

- What barriers exist to deeper integration?
- What student preparation would be necessary?
- How might agency levels progress across a program?

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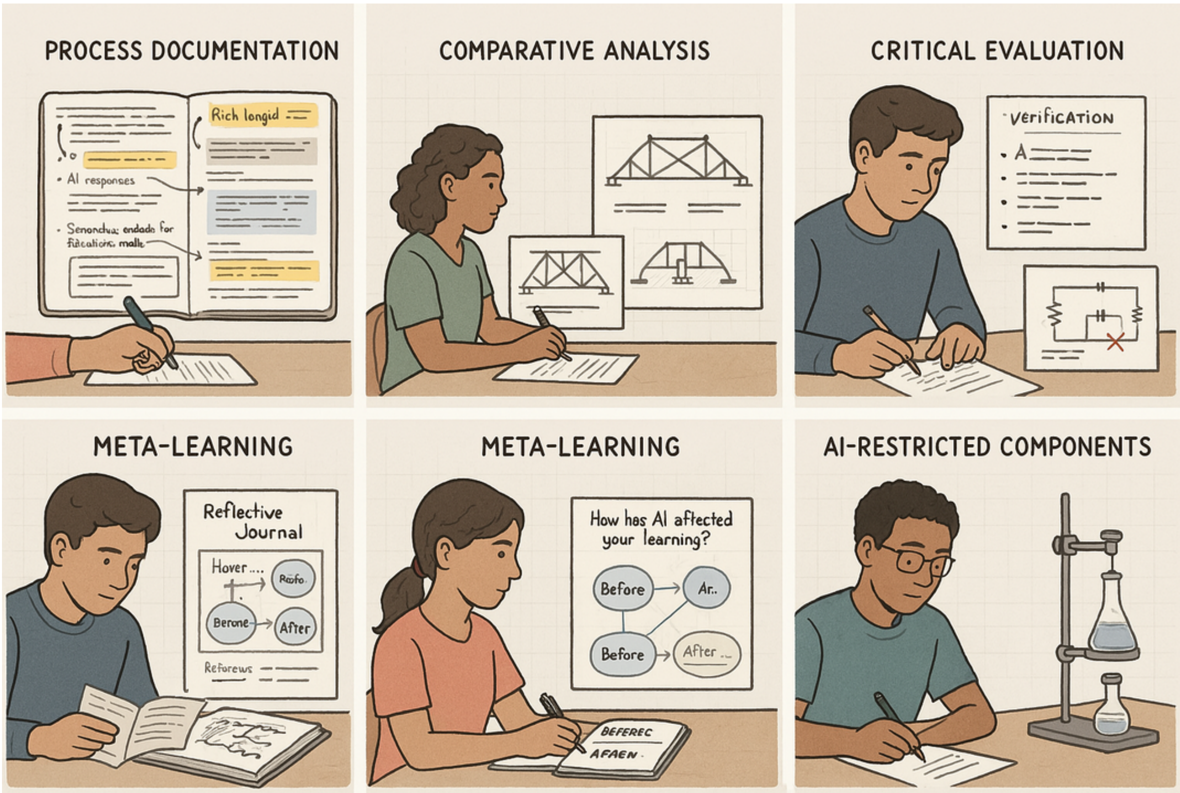
## 4. Assessment Alignment Dimension

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## 4. Assessment Alignment Dimension

**Assessment approaches:**

- **Process Documentation**
  *Evaluating AI use in workflow*
- **Comparative Analysis**
  *Evaluating AI outputs vs. alternatives*
- **Critical Evaluation**
  *Verifying and refining AI contributions*
- **Meta-Learning**
  *Reflection on learning with AI*

- **AI-Restricted Components**
  *Some assessment without AI*

**Engineering Example:**

In electrical engineering circuit design:

- Students document their prompting strategies
- Compare AI suggestions with manual calculations
- Identify and correct errors in AI recommendations
- Reflect on how AI affected their design process
- Still complete fundamental circuit analysis manually

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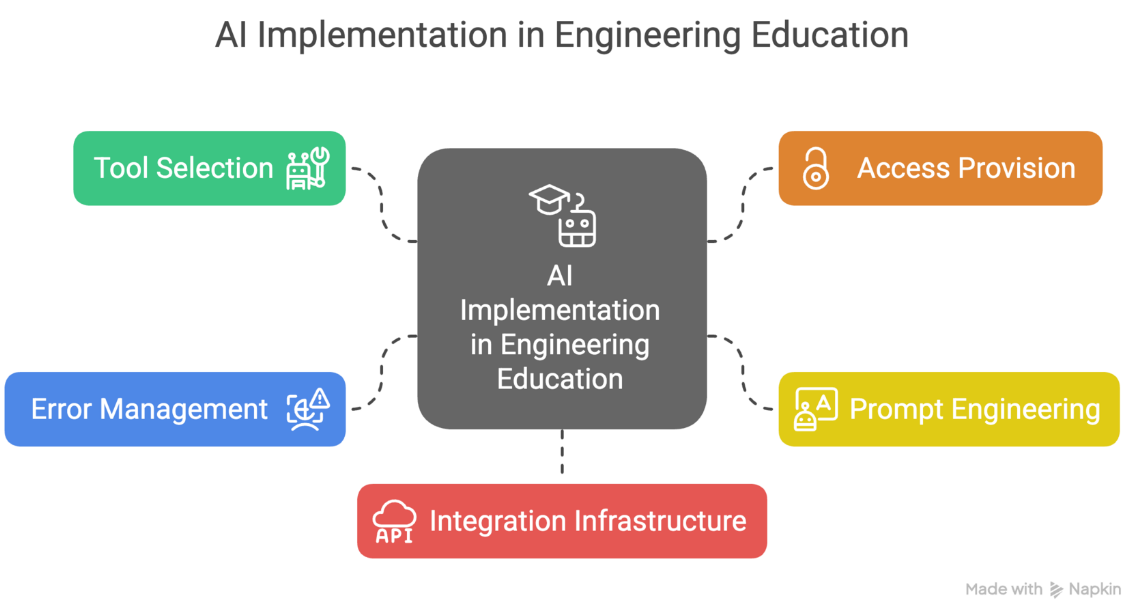
## 5. Technical Implementation Dimension

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## 5. Technical Implementation Dimension

**Implementation aspects:**

- **Tool Selection**
  *Matching capabilities to objectives*
- **Access Provision**
  *Ensuring equitable student access*
- **Prompt Engineering**
  *Developing effective prompts*
- **Error Management**
  *Handling AI limitations*
- **Integration Infrastructure**
  *Technical platforms for delivery*

**Engineering Examples:**

- Civil engineering using Whisper for field note transcription
- Chemical engineering using DALL-E for safety visualization
- Mechanical engineering using ChatGPT for ideation
- Each tool selected for specific capabilities aligned with learning goals

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## Assessment & Technical

> **Note**
>
> **Reflect on the following:**
>
> 1. What assessment challenges do you anticipate with AI integration?
> 2. What technical implementation concerns are most relevant in your context?
> 3. What strategies might address these challenges?

**Consider:**

- Balancing individual mastery with AI assistance
- Technical resources available in your department
- Student access and equity issues
- Discipline-specific technical needs

## 6. Ethical & Professional Development Dimension

**Ethical aspects:**

- **Attribution Practices**
  *Citation of AI contributions*
- **Professional Norms**
  *Alignment with industry practices*
- **Critical AI Literacy**
  *Understanding capabilities and limitations*
- **Responsible Use**
  *Ethical decision-making*
- **Equity Considerations**
  *Benefits reaching all students*

**Engineering Example:**

Across disciplines:

- Developing AI contribution statements
- Consulting with industry on current practices
- Teaching systematic verification of AI outputs
- Discussing societal implications of AI in engineering
- Addressing varying levels of prior AI experience

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## Ethical & Professional: Brief Discussion

> **!** Important
>
> **Reflect on the following:**
> What ethical considerations are particularly important in your engineering discipline?

**Consider:**

- How is your industry using AI tools?
- What ethical concerns are specific to your field?

- How might AI use affect different student populations?
- What professional skills should students develop?

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## Implementation Examples by Discipline

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## Implementation Examples by Discipline

There are detailed example implementations that map to different positions on the taxonomy:

- **Mechanical:** Concept visualization in thermodynamics (Conceptual Understanding, Guided Integration)
- **Electrical:** Circuit analysis feedback (Skill Development, Embedded Practice)

- **Civil:** Structural design iterations (Process Augmentation, Transformative Redesign)
- **Chemical:** Safety visualization (Visualization, Scaffolded Autonomy)
- **Computer Science:** Algorithm development with Copilot (Skill Development, Guided Exploration)

*These examples include detailed implementation steps, sample prompts, and assessment strategies*

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## Prompt Engineering in Engineering Education

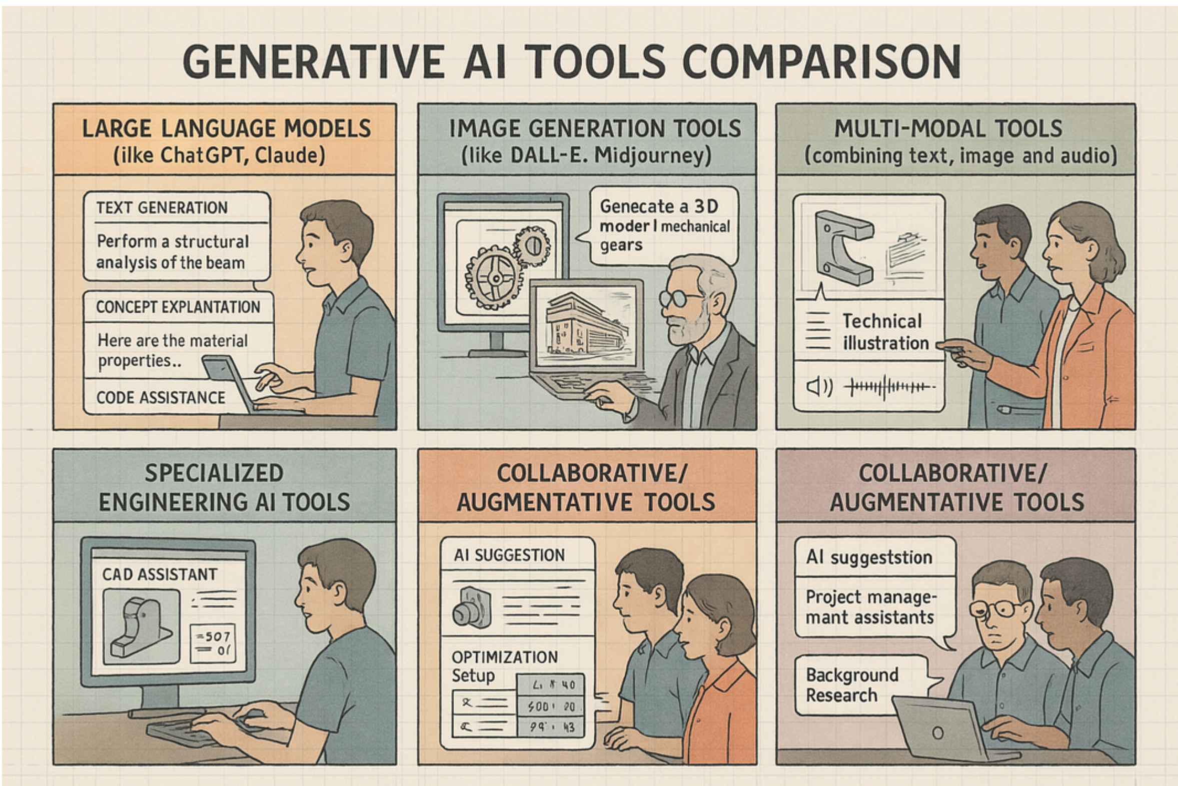


Figure 1: Generative Tools

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## Prompt Engineering in Engineering Education

**Key principles for effective prompts:**

- Be specific about engineering context
- Include relevant technical parameters
- Clarify expected detail/technical level
- Request verification steps
- Include format specifications
- Consider iterative prompt chains

**Example: From general to specific**
"Explain entropy"
"Explain entropy from statistical mechanics perspective for junior-level thermodynamics students"

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## Prompt Engineering in Engineering Education

**Sample prompt structures:**

1. **Conceptual explanation prompt:**
    - Multiple perspective requests
    - Connection to applications
    - Misconception identification
2. **Technical verification prompt:**
    - Solution review with error identification
    - Underlying principle explanation
    - Alternative approach suggestion
3. **Design exploration prompt:**
    - Multiple solution generation
    - Constraint-based evaluation
    - Trade-off analysis

*See ideeaslab.com/resources for prompt templates*

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## Assessment Redesign Principles

**Moving beyond traditional assessment in AI-integrated courses:**

- **Assess the Process:** Documentation of AI interactions, decision-making, verification
- **Focus on Higher-Order Skills:** Engineering judgment, critical evaluation, constraint analysis
- **Maintain Knowledge Verification:** Targeted components without AI assistance
- **Balance Product and Process:** Evaluate both outcomes and the methods used
- **Clear Attribution Standards:** Consistent guidelines for documenting AI contributions

> Tip
>
> Rubric elements should reward critical thinking about AI outputs, not just the final product quality. Good rubrics include evaluation of verification strategies and decision rationale.

*See the example Assessment Redesign Guide for detailed rubrics and examples*

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## Implementation Challenges & Solutions

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## Implementation Challenges & Solutions

**Common Challenges:**

- Varying student AI literacy levels
- Technical accuracy verification
- Equity of access to AI tools
- Balance of efficiency vs. learning
- Academic integrity considerations
- Rapid tool evolution
- Student overreliance on AI

**Effective Solutions:**

- Scaffolded introduction with baseline training
- Create verification protocols and checklists

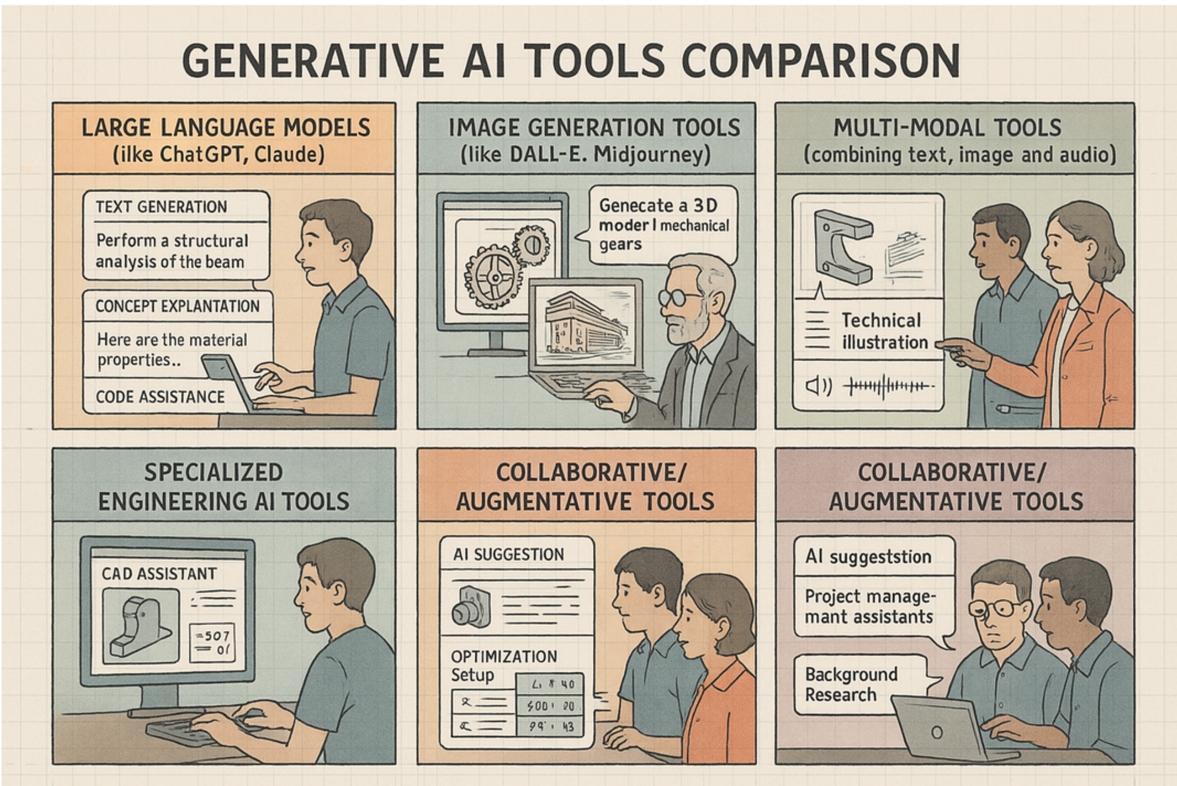


Figure 2: Integration Challenges

- Provide institutional or classroom access
- Focus assessment on process and reflection
- Develop clear attribution guidelines
- Emphasize transferable skills beyond tools
- Design assignments requiring critical evaluation

*Challenge intensity varies by integration depth and student agency level*

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## Application & Planning

### Case Study Analysis Activity

**Small Group Activity (15 minutes):**

1. Each group will analyze one case study using the taxonomy
2. Map the case to each dimension of the taxonomy
3. Identify key integration decisions and their rationale
4. Discuss how similar approaches might apply to your contexts
5. Select one key insight to share with the full group
6. The cases are available at ideeaslab.com/resources/teaching and selecting "Case Study" from the Resource Typedropdown menu

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### Case Studies Available

- **Mechanical Engineering:** ChatGPT for Design Ideation
  *Enhancing ideation while maintaining design decision ownership*
- **Electrical Engineering:** Claude for Circuit Analysis Feedback
  *Progressive circuit feedback with verification of technical accuracy*
- **Civil Engineering:** Whisper for Accessible Materials
  *Automatic transcription enhancing access to field experience*
- **Chemical Engineering:** DALL-E for Safety Visualization
  *Visualizing hazards and failure modes through image generation*
- **Thermodynamics:** ChatGPT for Concept Mastery
  *Multiple concept representations to deepen understanding*

- **Data Structures:** GitHub Copilot for Algorithm Implementation
  *Focusing on algorithm design patterns over syntax details*
- **Materials Science:** Claude for Multi-scale Understanding
  *Bridging nano, micro, and macro perspectives with AI explanations*

> Tip
>
> Each case study maps to different positions along the taxonomy dimensions

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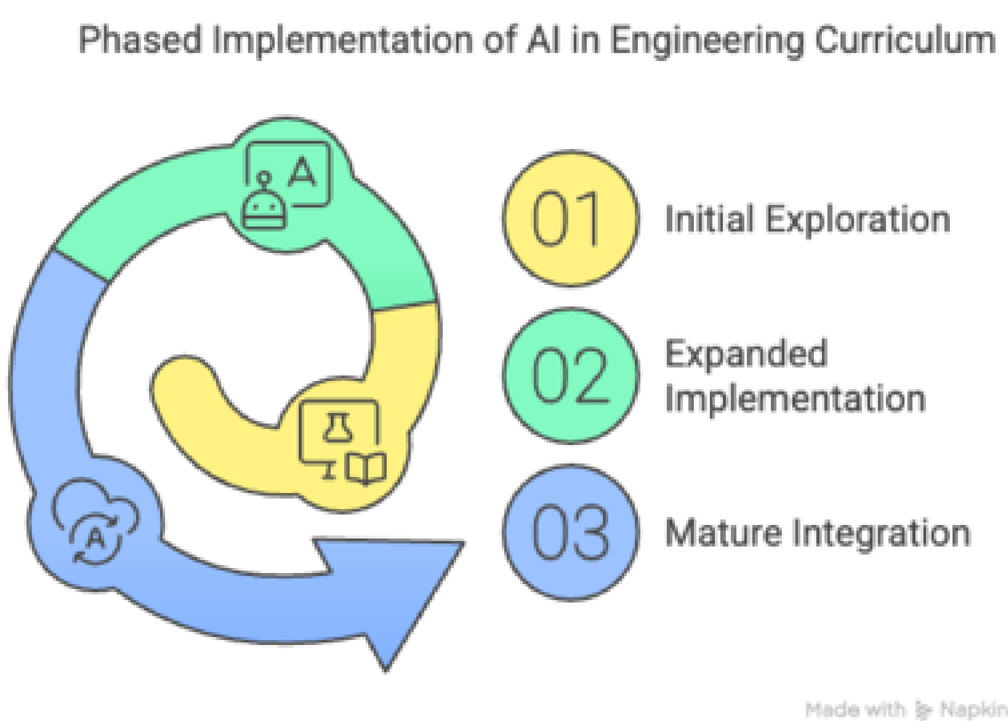
### Implementation Planning

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### Implementation Planning

**Individual Work (15 minutes):**

1. Select one course for potential AI integration
2. Complete the Implementation Planning Template
3. Map current position on each taxonomy dimension
4. Choose target positions that align with course goals
5. Identify specific implementation steps for 1-2 priority dimensions
6. Document anticipated challenges and resources needed
7. Share plan with a partner for feedback (5 minutes)

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### Example Implementation Plan

**Course:** Thermodynamics II (Junior-level)

**Current State:** * No formal AI integration * Students using AI unofficially * Traditional problem-based assessment * Conceptual understanding challenges with entropy, availability, and multi-scale phenomena

**Priority Dimensions:** 1. Pedagogical Purpose (Conceptual Understanding) 2. Assessment Alignment (Process Documentation) 3. Student Agency (Scaffolded Autonomy)

**Implementation Actions:** 1. Create prompt library for thermodynamic concepts 2. Develop visual representation activities using image AI 3. Design concept mapping assignment with AI feedback 4. Implement verification protocols for AI explanations 5. Create process portfolio assessment structure 6. Pilot with entropy unit before full implementation

**Resources Needed:** * Example prompt collection for key concepts * Image generation tool access (DALL-E) * LMS integration for documentation * Assessment rubrics focused on concept mastery * Student guidance for critical AI evaluation

*Based on the detailed example in our workshop materials*

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### Key Takeaways

- **Intentional integration** is key to effective AI use in engineering education
- The **taxonomy framework** provides multiple dimensions to consider for implementation
- Different dimensions may be **prioritized** based on specific course challenges and goals
- **Progressive implementation** often works better than complete redesign
- **Assessment alignment** is critical for meaningful integration
- Consider implications for **student professional development**

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### Resources Available

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### Resources Available

- **Workshop Materials**
  - Expanded Case Studies by Discipline
  - Prompt Libraries for Engineering Contexts
  - Assessment Examples and Rubrics
  - Implementation Planning Guides

**Contact Information:** Dr. Andrew Katz Email: akatz4@vt.edu

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### Next Steps & Questions

**Next Steps:** 1. Complete your implementation plan 2. Identify one small action to take in the next month 3. Consider forming discipline-specific implementation groups 4. Explore additional resources provided

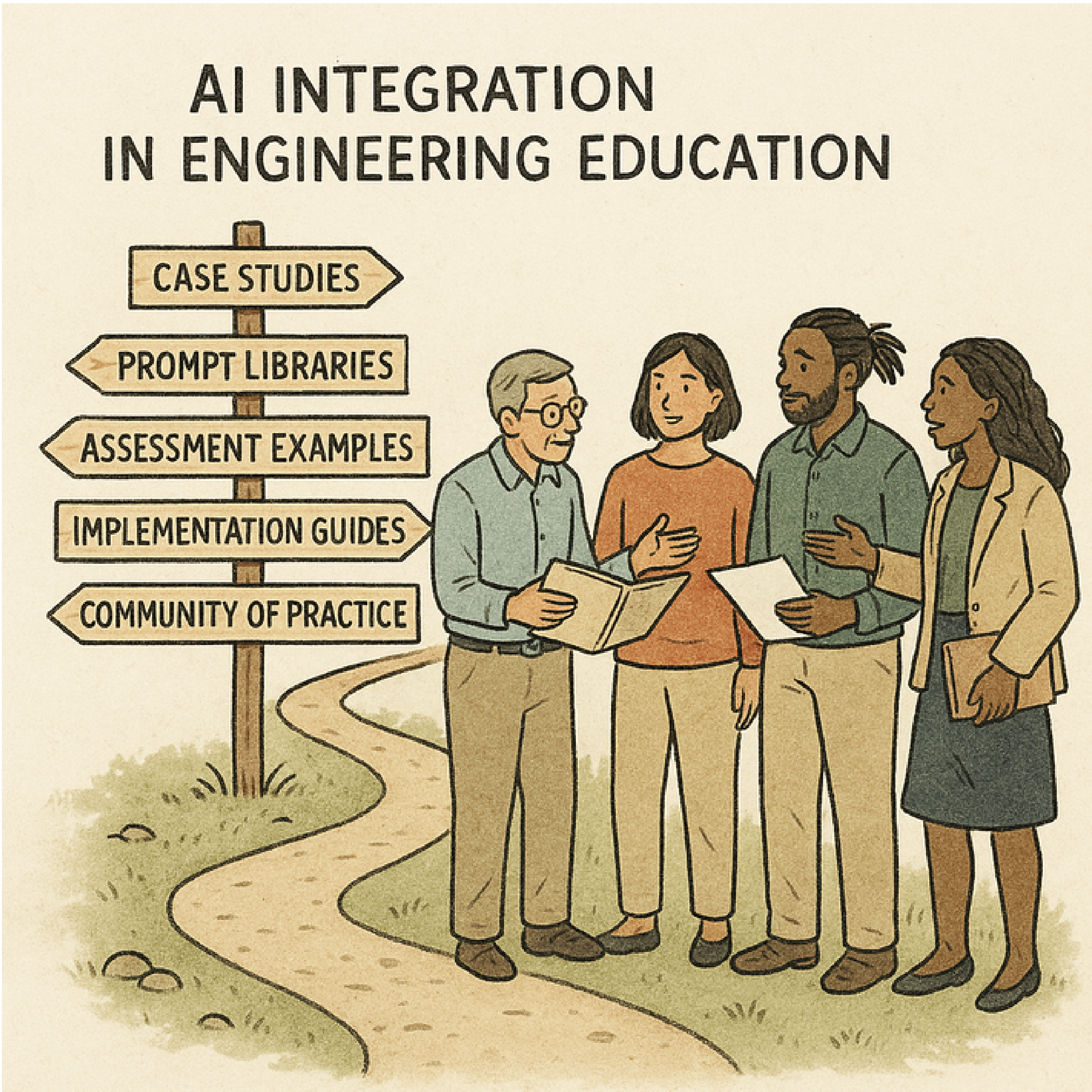


Figure 3: Resources and Next Steps

> **!** Important
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> **Questions & Discussion**
> What questions do you have about implementing AI in your engineering courses?

**Thank you for your participation!**