AI Integration Taxonomy for Engineering Education

# AI Integration Taxonomy for Engineering Education

This document summarizes the six dimensions of the AI integration taxonomy that serves as a framework for implementing generative AI in engineering education. Each dimension represents a key consideration when designing AI-enhanced educational experiences.

## 1. Pedagogical Purpose Dimension

This dimension focuses on the primary educational goals that AI integration aims to support:

* **Conceptual Understanding**: Using AI to explain complex engineering concepts, address misconceptions, and provide multiple perspectives on difficult topics
* **Skill Development**: Leveraging AI to bypass technical hurdles, allowing students to focus on higher-order engineering skills
* **Process Augmentation**: Enhancing engineering workflows and methodologies with AI assistance
* **Content Creation**: Using AI to generate or transform educational materials
* **Visualization & Representation**: Helping students visualize complex phenomena and abstract concepts in engineering

## 2. Integration Depth Dimension

This dimension describes the extent to which AI is incorporated into course structure:

* **Supplemental Resource**: AI tools offered as optional resources outside the core instructional activities
* **Guided Integration**: Structured AI activities with specific prompts for designated course components
* **Embedded Practice**: AI integrated throughout regular coursework as a standard part of engineering practice
* **Transformative Redesign**: Course completely restructured around AI capabilities, focusing on skills that complement AI

## 3. Student Agency Dimension

This dimension addresses how much autonomy students have in their AI use:

* **Instructor-Directed**: Faculty provides specific prompts and tools for specific purposes with little student choice
* **Scaffolded Autonomy**: Students given progressive responsibility with structured guidance on effective AI use
* **Guided Exploration**: Students experiment with AI tools within established boundaries and guidelines
* **Full Autonomy**: Students make independent decisions about when and how to use AI in their engineering work

## 4. Assessment Alignment Dimension

This dimension focuses on how learning assessment adapts to AI integration:

* **Process Documentation**: Evaluating how students use AI in their engineering workflow
* **Comparative Analysis**: Assessing students’ ability to evaluate AI outputs against alternatives
* **Critical Evaluation**: Measuring how students verify and refine AI contributions
* **Meta-Learning**: Assessing students’ reflection on how AI affects their engineering learning process
* **AI-Restricted Components**: Maintaining some assessment components that prohibit AI use

## 5. Technical Implementation Dimension

This dimension addresses the practical aspects of implementing AI in engineering courses:

* **Tool Selection**: Matching AI capabilities to specific engineering learning objectives
* **Access Provision**: Ensuring equitable student access to AI tools
* **Prompt Engineering**: Developing effective engineering-specific prompts for AI tools
* **Error Management**: Developing strategies to handle AI limitations and errors
* **Integration Infrastructure**: Creating technical platforms and workflows for AI delivery

## 6. Ethical & Professional Development Dimension

This dimension focuses on responsible AI use in engineering contexts:

* **Attribution Practices**: Proper citation and acknowledgment of AI contributions
* **Professional Norms**: Alignment with current and emerging industry practices for AI use
* **Critical AI Literacy**: Understanding AI capabilities, limitations, and potential biases
* **Responsible Use**: Developing ethical decision-making skills around AI use in engineering
* **Equity Considerations**: Ensuring AI benefits reach all students and addressing potential inequities

## Applications of the Taxonomy

This taxonomy can be used to:

1. **Analyze existing implementations** of AI in engineering education
2. **Plan new integration efforts** by considering each dimension systematically
3. **Identify areas for development** in current AI integration approaches
4. **Communicate with stakeholders** about the pedagogical foundations of AI integration
5. **Guide assessment design** for AI-enhanced engineering courses

The dimensions are designed to be flexible and adaptable across different engineering disciplines, course levels, and institutional contexts. Each implementation will prioritize different dimensions based on specific course needs, instructor preferences, and learning objectives.

*This taxonomy was developed to provide a comprehensive framework for implementing generative AI in engineering education.*