Integrating ChatGPT in a Mechanical Engineering Design Course

## Downloads

* [Download as Word Document (DOCX)](/downloads/teaching/mechanical-design-chatgpt.docx)

# Case Study: Integrating ChatGPT in a Mechanical Engineering Design Course

## Course Context

**Course:** Advanced Mechanical Design (ME 4054)
**Level:** Senior
**Enrollment:** 45 students
**Prior Format:** Team-based capstone design projects with client specifications
**Tools:** CAD software, simulation tools, physical prototyping
**Faculty:** Dr. C, Professor of Mechanical Engineering

## Implementation Goals

Dr. C identified several opportunities for AI integration in his design course:

1. **Enhance Ideation:** Overcome design fixation and expand students’ solution space
2. **Streamline Documentation:** Improve technical writing while maintaining student understanding
3. **Design Critique:** Provide additional feedback channels beyond instructor and peers
4. **Client Communication:** Help students craft professional communications with industry sponsors
5. **Knowledge Integration:** Connect theoretical concepts from prior courses to design applications

## Implementation Process

### Phase 1: Faculty Preparation (1 month before semester)

1. **Tool Exploration:**
	* Completed OpenAI’s Educator Training Program
	* Created custom project-specific prompt templates
	* Tested different prompting strategies for design tasks
	* Identified common failure modes and limitations
2. **Course Material Adaptation:**
	* Redesigned design review rubrics to include AI-assisted components
	* Created scaffolded prompting guides for each design phase
	* Developed evaluation criteria for assessing AI-human collaboration
	* Created example “good” and “poor” AI interaction demonstrations
3. **Policy Development:**
	* Established clear guidelines on appropriate vs. inappropriate AI use
	* Developed AI usage documentation requirements
	* Created templates for citing AI contributions in design reports

### Phase 2: Student Introduction (First two weeks)

1. **AI Design Workshop (75-minute session):**
	* Conducted hands-on training on effective prompting for design tasks
	* Demonstrated strategies for critiquing and improving AI-generated content
	* Facilitated small group practice with design-specific prompts
	* Discussed ethical considerations in AI-assisted design
2. **Progressive Integration:**
	* Started with low-stakes practice activities using AI for brainstorming
	* Introduced AI-assisted documentation after core concepts were established
	* Built up to more complex design evaluations and trade-off analyses
3. **Documentation Framework:**
	* Implemented AI interaction logs recording:
		+ Prompt strategies and iterations
		+ Critical evaluation of AI-generated content
		+ Design decisions informed by AI suggestions
		+ Limitations encountered and workarounds developed

### Phase 3: Design Project Implementation (Throughout semester)

1. **Ideation Phase Integration:**
	* Teams used ChatGPT to expand initial concept generation
	* Required documentation of which concepts were human-generated vs. AI-generated
	* Teams evaluated and refined AI suggestions based on engineering criteria
	* Students presented comparative analysis of human and AI-generated concepts
2. **Analysis and Refinement Phase:**
	* AI-assisted development of testing protocols
	* Collaborative enhancement of design calculations
	* AI-supported risk and failure mode analyses
	* Regular reflection on which tasks benefited most from AI assistance
3. **Documentation and Presentation:**
	* AI-assisted technical writing with student critical refinement
	* Human-AI collaborative development of visual presentation materials
	* Required “AI contribution statements” in final documentation
	* Reflection on professional applications of AI-assisted design

## Implementation Examples

### Example 1: Concept Generation Prompt Evolution

**Initial Student Prompt:**

Generate ideas for a device that helps elderly people pick up objects from the floor without bending down.

**Enhanced Student Prompt After Training:**

I'm working on a mechanical engineering design project to help elderly people (ages 65+)
with limited mobility pick up objects from the floor without bending down.

The device should:
- Be usable by someone with limited grip strength and dexterity
- Cost under $100 to manufacture
- Be lightweight (under 2 pounds)
- Require no external power if possible
- Store compactly when not in use
- Accommodate picking up objects of different sizes (from pills to TV remotes)

Please generate 8 conceptually different design approaches that use different mechanical
principles. For each concept:
1. Provide a descriptive name
2. Explain the core mechanical principle/mechanism
3. Identify one key advantage and one limitation
4. Suggest one way the limitation might be addressed

Do not suggest purely electronic solutions or ones that require advanced robotics.

### Example 2: Design Critique Integration

**Assignment Component:** > For this design review milestone, you will use both peer feedback and AI-assisted critique. After receiving initial peer feedback, use the AI critique prompt template to gather additional design insights. In your revised design document, include a section titled “Design Iteration Process” that compares peer and AI feedback, explaining which suggestions you incorporated and why.

**Student Prompt Template:**

I am a mechanical engineering student working on a [specific project] design.
I would like you to review my current design approach and provide constructive feedback.

My current design:
[Student inserts design description here]

Key specifications:
[Student inserts specifications here]

My current concerns:
[Student inserts concerns here]

Please analyze my design and provide feedback in the following categories:
1. Mechanical efficiency and functionality
2. Manufacturing feasibility
3. Potential failure modes I may have overlooked
4. Suggestions for simplification or cost reduction
5. Questions I should address in my next design iteration

For each suggestion, please explain the engineering principle or rationale behind it.

### Example 3: AI-Enhanced Technical Documentation

**Assignment Component:** > Draft your technical documentation section using appropriate engineering terminology and standards. Then, use the AI enhancement prompt to identify areas for improvement. Submit both your original draft and your revised version, along with a brief reflection on how the AI feedback improved your technical writing.

**Student Documentation Workflow:** 1. Students wrote initial technical documentation draft 2. Used ChatGPT to receive feedback on clarity, completeness, and technical accuracy 3. Evaluated AI suggestions and selectively incorporated improvements 4. Documented which changes were made based on AI feedback and why 5. Reflected on technical communication skills development

## Assessment Approaches

### Traditional vs. AI-Integrated Assessment

#### Before: Standard Design Report Rubric

* Concept generation: Quantity and variety of concepts (10%)
* Engineering analysis: Accuracy and depth (25%)
* Final design: Quality and functionality (30%)
* Documentation: Clarity and completeness (20%)
* Presentation: Organization and delivery (15%)

#### After: AI-Enhanced Design Process Rubric

* Concept generation: Quality of human-AI collaborative ideation (10%)
* Critical evaluation: Analysis of AI-generated suggestions (15%)
* Engineering analysis: Accuracy, depth, and verification of calculations (20%)
* Final design: Quality, functionality, and innovation (25%)
* Documentation: Clarity, completeness, and appropriate AI citation (15%)
* Process reflection: Insights on human-AI collaboration (15%)

### Evaluation of AI Integration

Dr. C developed specific criteria for evaluating students’ AI usage:

1. **Prompt Effectiveness:** Quality and specificity of prompts created
2. **Critical Evaluation:** Ability to assess AI outputs against engineering principles
3. **Iterative Refinement:** Strategic improvement of prompts based on initial results
4. **Integration Judgment:** Appropriate decisions about when to use AI vs. human work
5. **Metacognitive Awareness:** Insights about their own design process through AI interaction

## Potential Outcomes and Considerations

### Expected Benefits

* Expanded solution space and reduced design fixation
* More robust design documentation and communication
* Increased student comfort with ambiguity and iteration
* More time for physical prototyping and testing
* Greater focus on design evaluation rather than production of design artifacts

### Potential Challenges

* Some students may be initially resistant to AI tools
* Risk of uncritical acceptance of AI suggestions
* Potential over-reliance on AI for documentation
* Varying skill development in prompt engineering
* Additional instructor preparation time required

## Faculty Implementation Considerations

### Key Implementation Strategies

1. **Scaffolded introduction** to AI tools with progressive complexity
2. **Documentation requirements** that emphasize critical thinking
3. **Comparative analysis** between human and AI-generated content
4. **Process-oriented assessment** rather than just final product evaluation
5. **Regular reflection** on appropriate use and limitations

### Important Considerations

1. **Prior exposure varies widely** among students, requiring differentiated support
2. **Explicit instruction in prompt engineering** is essential for effective use
3. **Technical validation remains critical** as AI can suggest plausible but flawed approaches
4. **Client/stakeholder communication** about AI use needs careful management
5. **Finding the right balance** between AI assistance and independent work requires ongoing adjustment

### Future Refinement Directions

If implementing such an approach, consider: 1. Developing a structured prompt library for specific design tasks 2. Creating formal training on evaluating AI-generated engineering content 3. Implementing peer review of prompt strategies alongside design reviews 4. Including industry perspective on real-world AI use in design processes 5. Integrating AI tools with existing design software and documentation systems

## Resources Provided

1. **Prompt Templates:** Task-specific prompting guides for various design phases
2. **AI Interaction Logs:** Documentation templates for recording AI collaborations
3. **Evaluation Rubrics:** Assessment criteria for AI-enhanced design processes
4. **Ethical Guidelines:** Framework for appropriate AI use in engineering design
5. **Integration Roadmap:** Phased implementation plan for other courses

## Implementation Advice

### For Faculty Considering Similar Integration:

1. **Start with ideation and documentation** where AI can add immediate value
2. **Create clear guidelines** about when AI use is appropriate vs. not recommended
3. **Develop specific prompting strategies** for your engineering discipline
4. **Teach critical evaluation skills** alongside AI implementation
5. **Emphasize design justification** rather than just design outputs

### Common Pitfalls to Avoid:

1. **Overlooking validation** of AI-suggested approaches against physics and engineering principles
2. **Assuming uniform AI literacy** among students
3. **Underestimating documentation needs** for tracking AI contributions
4. **Focusing only on product** rather than enhancing process
5. **Insufficient attention** to ethical considerations in AI-assisted design

*This case study was developed as part of the “Strategies for Integrating Generative AI in Engineering Education” workshop materials in collaboration with ChatGPT.*