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# Practical Integration of Generative AI in Aerospace Engineering Education: Multi-Institutional Experience and Recommendations

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*ABSTRACT*

**The rapid emergence of generative artificial intelligence tools, particularly large language models such as ChatGPT, has created both opportunities and uncertainties in aerospace engineering education. While these tools offer potential benefits for learning, research, and professional development, many educators and institutions struggle with how to integrate them responsibly into curricula. This paper presents practical experience from implementing generative AI education across multiple institutions and course contexts, with specific focus on aerospace engineering with some guidance, navigation and control topics. The paper describes the evolution of a mini-course on responsible generative AI use, from its initial implementation as a voluntary session to its integration into graduate-level orbital mechanics coursework and subsequent adaptation for faculty development at multiple universities including Politecnico di Milano. The primary contribution is a tested framework for introducing generative AI tools to engineering students and faculty, emphasizing responsible use, critical thinking, and practical applications in technical coursework. Some preliminary evidence from student projects demonstrates that properly guided AI integration can enhance learning efficiency in complex technical subjects including orbital mechanics and trajectory optimization, while maintaining academic integrity and fostering appropriate skepticism of AI-generated content.**

**Keywords:** engineering education, generative AI, aerospace education, responsible AI use, orbital mechanics

## 1 Introduction and Motivation

Generative artificial intelligence, particularly large language models such as ChatGPT, Claude, and similar tools, has transformed knowledge work across industries since late 2022 [1, 2]. The aerospace engineering community faces a critical question: how should these powerful tools be integrated into education and professional practice? Similar questions have emerged across educational domains, from medical education [3] to engineering disciplines. Many institutions have responded with policies ranging from outright bans to unstructured acceptance. Governmental and institutional bodies have begun issuing policy frameworks—the European Commission published ethical guidelines for AI use in teaching and learning [4], while the EU Artificial Intelligence Act classifies education as a high-risk domain for AI deployment [5]. At the institutional level, some universities have issued general guidelines encouraging AI adoption while urging caution—for example, Universidad de Sevilla published a broad set of principles for generative AI use in teaching [6]—but these documents typically lack actionable guidance for specific disciplines. Yet few institutions have developed systematic approaches to teaching responsible and effective AI use within technical disciplines.

The challenge is particularly acute in guidance, navigation and control education, where students must develop deep understanding of mathematical foundations, physical intuition, and practical implementation skills. Generative AI offers potential benefits—rapid prototyping of code, explanation of complex concepts, assistance with technical writing—but also risks including over-reliance, reduced learning depth, and propagation of errors in safety-critical applications.

This paper presents practical experience from two years of implementing generative AI education in aerospace engineering contexts [7]. The work began with a two-hour mini-course designed to demystify AI tools and establish principles for responsible use, evolved into systematic integration within a graduate orbital mechanics course, and expanded to faculty development programs at multiple institutions and even some companies. The goal throughout has been pragmatic: equip students and faculty with skills to leverage AI productively while maintaining technical rigor and critical thinking.

The structure of this paper is as follows: Section 2 describes the educational context and evolution of the AI integration approach across different course implementations. Section 3 presents practical recommendations for GNC educators based on lessons learned. Section 4 provides detailed course materials and implementation examples. Section 5 analyzes student outcomes and presents case studies. Section 6 discusses faculty perspectives and institutional implications. Section 7 offers concluding thoughts on long-term implications for aerospace engineering education and the paper is closed with some remarks in Section 8.

# 2 Educational Context and Course Evolution

## 2.1 Initial Mini-Course Design (2023)

The first implementation occurred as a voluntary laboratory session following an undergraduate orbital mechanics course at Universidad de Sevilla. Thirteen fourth-year students participated in a two-hour introduction covering:

- Fundamentals of large language models: architecture, training, limitations
- Prompt engineering techniques for technical applications
- Practical demonstrations of code generation (MATLAB/Python)
- Academic writing assistance and limitations
- Ethical considerations and responsible use principles
- Hands-on exercises with ChatGPT

Students were assigned a project: produce a technical report and presentation on a space-related topic (which included e.g. topics as diverse as space debris, near-Earth objects, Gauss's Ceres discovery, halo orbits, or Pluto's reclassification as a dwarf planet) using AI tools responsibly. The assignment explicitly required students to document their AI usage, verify all claims with proper references, and add original analysis beyond AI-generated content.

Results were mixed but informative. Two students produced exceptional work, demonstrating sophisticated understanding of how to use AI as a research accelerator while maintaining intellectual ownership. They used ChatGPT for initial outlining, expanded sections independently, cross-referenced AI suggestions with authoritative sources, and employed the tool for language refinement and LaTeX formatting. Several other students, however, submitted superficial work with minimal citations, revealing gaps in their ability to critically evaluate AI output.

This experience highlighted a critical insight: introducing the tool is insufficient. Students require explicit guidance on verification, source evaluation, and integration of AI assistance with independent thinking.

## 2.2 Integration into Graduate Coursework (2024-2026)

Following the initial experiment, generative AI was systematically integrated into a graduate course on Applied Orbital Mechanics, offered three times (2024, 2025, 2026) with growing enrollment (20, 25, and 40 students respectively). Rather than treating AI as a separate topic, it was positioned as one of several professional tools students should master, alongside MATLAB, Python, and technical writing.

Key assignments incorporated AI explicitly:

**Professional communication**: As a first exercise, students wrote cover letters for aerospace positions. These were evaluated by both the professor and two AI systems (ChatGPT-4 and Gemini), using an AI-generated rubric. Students received comparative feedback, learning to understand how AI evaluates communication while recognizing that human judgment considers context AI cannot access.

**Technical problem-solving**: Homework assignments in trajectory optimization and orbit determination permitted AI assistance for code structure and debugging. Students were required to document what assistance they sought, evaluate the quality of AI suggestions, and explain their final implementation choices. This approach made AI use transparent while maintaining accountability for correctness.

**Concept explanation**: Students could use AI to generate initial explanations of complex topics (Lagrange points, perturbation theory, Lambert's problem), but were required to verify accuracy against course materials and add worked examples demonstrating their understanding.

The integration revealed that AI is most valuable for:

- Rapid prototyping of algorithmic approaches
- Generating template code structures
- Explaining unfamiliar mathematical notation
- Reformulating problems to identify solution approaches
- Polishing technical writing for clarity

It proved least reliable for:

- Specialized GNC algorithms without extensive context
- Numerical method selection for specific problem characteristics
- Understanding physical limitations and engineering constraints
- Generating accurate technical references

## 2.3 Faculty Development and Multi-Institutional Adoption

Student demand led to additional sessions for third-year undergraduates and, unexpectedly, interest from university administration in faculty development. A six-hour version of the course was created for professors, incorporating more extensive hands-on practice and discussion of pedagogical implications, and several versions of this course have been taught during the last year.

Moreover, the course was adapted and delivered to faculty in the aerospace engineering departments at Politecnico di Milano and other institutions different from the home university of the author. These sessions focused on practical questions faculty face: How to update assignment design to account for AI availability? How to assess student work when AI assistance is ubiquitous? How to teach with AI tools rather than simply about them?

Beyond pedagogical considerations, faculty expressed strong interest in leveraging AI to improve their own productivity—generating course materials, creating assessment rubrics, drafting routine correspondence, and automating repetitive administrative tasks. Some colleagues reported significant time savings in course preparation and administrative workflows after adopting AI assistance for appropriate tasks.

Throughout the various offerings, the range of generative AI tools covered evolved with the rapidly changing landscape. Early sessions in 2023 focused primarily on ChatGPT (GPT-3.5, free tier). By 2024–2025, sessions incorporated a multi-tool approach covering ChatGPT (GPT-4, GPT-4o), Claude (Anthropic), Gemini (Google), Copilot (Microsoft), Perplexity, DeepSeek, Mistral, and Grok, using both free and paid versions. This breadth allowed participants to compare capabilities across platforms and avoid over-reliance on any single tool.

Table 1 summarizes the scope of the educational initiative across institutions. In total, the initiative reached over 550 participants across academic and professional settings. At Universidad de Sevilla alone, five editions of faculty workshops enrolled 361 participants with a 64.8% completion rate.

**Table 1 Summary of generative AI course offerings across institutions.**

| Institution | Audience | Duration | Year | Part. |
|---|---|---|---|---|
| Univ. Sevilla (mini-course) | UG students | 2 h | 2023 | 13 |
| Univ. Sevilla (3rd year) | UG students | 2 h | 2023 | 10 |
| Univ. Sevilla (grad. course) | Grad students | Semester | 2024 | 20 |
| Univ. Sevilla (grad. course) | Grad students | Semester | 2025 | 25 |
| Univ. Sevilla (grad. course) | Grad students | Semester | 2026 | 40 |
| Univ. Sevilla (ICE, 3 editions) | Faculty | 6–9 h | 2024 | 250 |
| Univ. Sevilla (ICE, 2 editions) | Faculty | 9 h | 2025 | 111 |
| Politecnico di Milano | Faculty | 6 h | 2024 | 22 |
| Univ. Extremadura | Faculty | 5 h | 2024 | 28 |
| Univ. Valladolid | Faculty | 6 h | 2025 | 36 |
| Univ. Santiago de Compostela | Faculty | 6 h (online) | 2025 | 24 |
| ISDEFE | Professionals | 2×6 h | 2025 | 26 |
| Ag. Andaluza Antifraude | Professionals | 5 h | 2024 | 21 |
| Corp. Tecnol. de Andalucía | Professionals | 3 h | 2025 | 23 |

Faculty responses varied by discipline and generation. Younger faculty generally embraced AI as a productivity tool, while senior faculty expressed greater concern about fundamental skill erosion but demonstrated strong curiosity. Consensus emerged around several principles:

- Prohibition is futile; students will use available tools
- Transparency requirements reduce academic dishonesty concerns
- Assessment must evaluate understanding, not just results
- AI literacy is now a professional competency, not an optional skill

# 3 Practical Recommendations for GNC Educators

Based on implementation experience across diverse contexts, the following framework is recommended for introducing generative AI in GNC (and other technical fields) education:

## 3.1 Foundational Principles

Basic principles include:

**Demystify the technology**: Students benefit from basic understanding of how large language models work—probabilistic text prediction, context limits, tokenization, training data limitations. This reduces both excessive trust and irrational fear. A simple explanation that these models predict the next most likely word based on statistical patterns, rather than "understanding" content in a human sense, helps calibrate expectations appropriately.

**Emphasize verification**: Every AI-generated claim requires verification. For GNC applications, this means checking against textbooks, peer-reviewed literature, and physical constraints. Students must develop reflexive skepticism. The mantra "trust but verify" should become automatic when working with AI outputs, especially in safety-critical aerospace applications.

**Require transparency**: Assignment instructions should specify whether AI use is permitted and, if so, require documentation of what assistance was sought and how outputs were verified. This transparency serves dual purposes: it normalizes AI use as a tool rather than academic dishonesty, and it forces students to reflect on their AI interactions.

**Focus on understanding**: Assessment should probe comprehension rather than production. Written/oral examinations, whiteboard problem-solving, and explanation of trade-offs reveal whether students understand material regardless of how initial work was generated.

## 3.2 Practical Integration Strategies

**Start with low-stakes applications**: Introduce AI through formatting, language polishing, or brainstorming rather than core technical content. Build familiarity before high-stakes use. For example, students might first use AI to convert equations into LaTeX format or to improve the clarity of their technical writing.

**Compare AI and traditional approaches**: Assign problems where students solve using both classical methods and AI-assisted approaches, then compare efficiency, accuracy, and learning value. This metacognitive exercise helps students understand when AI adds value versus when it introduces unnecessary complexity or error.

**Use AI for teaching moments**: When AI generates incorrect GNC solutions (common for specialized algorithms), use these as opportunities to teach debugging, physical reasoning, and verification techniques. Having students identify and correct AI errors deepens understanding more effectively than simply providing correct solutions.

**Create AI-aware assessments**: Design assignments where AI assistance is expected and graded work evaluates synthesis, analysis, and critical evaluation rather than information retrieval or routine calculation. For instance, if asking students to produce code that solves the two-body problem (easily AI-generated), ask them to analyze precision, solvers, and possible alternative methods to the initially generated solution.

# 4 Course Materials and Implementation Examples

## 4.1 Sample Lesson Structure

The two-hour introductory session follows this structure:

**Introduction (15 minutes)**: Brief history of AI development, explanation of transformer architecture at conceptual level, discussion of training data and limitations. Key message: AI is a sophisticated pattern-matching tool, not an intelligence that understands physics or engineering.

**Prompt engineering (30 minutes)**: Hands-on demonstration of effective prompting techniques. Students practice iterative refinement of prompts for technical tasks. Examples include asking AI to solve the two body problem at different levels of sophistication, generate MATLAB code, generate visualization, and identify possible errors in sample code as well as analyze aspects such as precision, solvers, etc.

**Academic integrity discussion (20 minutes)**: Group discussion of what constitutes appropriate versus inappropriate AI use. Development of class guidelines collaboratively. This participatory approach increases student buy-in compared to top-down policies.

**Practical exercises (45 minutes)**: Students work in pairs on representative tasks: debugging code with AI assistance, using AI to outline a technical report, generating and verifying mathematical derivations, and reformatting equations for LaTeX.

**Wrap-up and assignment (10 minutes)**: Introduction of the project assignment, discussion of evaluation criteria, Q&A session.

## 4.2 Possible Assignment Specifications

The project assignment provides clear guidelines:

*Objective*: Produce a 4-6 page technical report on an assigned aerospace topic, demonstrating responsible use of generative AI tools.

*Requirements*:

- Include an appendix documenting all AI interactions
- Provide at least 5 authoritative references (textbooks, journals, NASA documents)
- Verify all technical claims against primary sources
- Include original analysis, calculations, or visualizations
- Explain how AI assistance enhanced your work and where it fell short

*Evaluation criteria*:

- Technical accuracy and depth (40%)
- Quality and appropriateness of references (20%)
- Original contribution beyond AI-generated content (20%)
- Effective documentation of AI use (10%)
- Critical reflection on AI limitations (10%)

This rubric explicitly rewards thoughtful AI integration while penalizing uncritical acceptance of AI outputs.

## 4.3 Example Prompts for GNC Applications

Effective prompts for aerospace engineering education include:

*Code generation*: "Generate Python code to propagate a two-body orbit using a Runge-Kutta integrator. Include comments explaining the physics and numerical method."

*Concept explanation*: "Explain the concept of specific impulse to an engineering student who understands basic physics but hasn't studied propulsion. Include the governing equation and its physical interpretation."

*Debugging assistance*: "This MATLAB code is supposed to calculate the delta-v for a Hohmann transfer but gives incorrect results. Help me identify potential issues. [paste code]"

*Problem reformulation*: "I need to design an attitude control system for a 3U CubeSat. What are the key parameters I need to specify, and what analysis approaches should I consider?"

Each prompt type serves a different learning objective and demonstrates appropriate AI use boundaries.

# 5 Student Outcomes and Case Studies

## 5.1 Qualitative Analysis of Student Work

Student projects from the initial 2023 mini-course and subsequent implementations reveal distinct patterns of AI use:

**High-quality exemplars**: The strongest student projects demonstrated:

- Strategic use of AI for initial research and outlining
- Systematic verification of AI claims against multiple authoritative sources
- Original synthesis that went beyond AI-generated summaries
- Transparent documentation of what AI contributed versus student analysis
- Critical evaluation of AI limitations encountered

One student investigating Gauss's orbit determination method for Ceres used ChatGPT to generate an initial timeline of the discovery, then verified and corrected dates against historical sources. The student independently worked through the mathematical approach, using AI only to check notation and generate LaTeX formatting. The result was a technically sound report that clearly distinguished historical facts from analytical content.

**Problematic patterns**: Weaker submissions showed:

- Heavy reliance on AI-generated text with minimal modification
- Superficial citations that did not verify technical claims
- Absence of original calculations or analysis
- Uncritical acceptance of AI explanations
- Minimal documentation of AI use

These patterns revealed that some students viewed AI as a shortcut to avoid work rather than a tool to enhance learning. This underscored the importance of assessment design that rewards understanding over production.

## 5.2 Hypothetical Scenario: Orbital Mechanics Problem-Solving

To illustrate the spectrum of AI use quality in technical coursework, consider a hypothetical scenario from a graduate Applied Orbital Mechanics course. Imagine students tackling a multi-part trajectory optimization problem with explicit permission to use AI assistance, such as designing a low-thrust transfer from Earth orbit to Mars orbit using a simplified dynamical model.

**Effective AI use pattern**: A student might begin by asking ChatGPT to outline solution approaches for low-thrust optimization problems. After receiving several suggestions, the student would research continuation methods in course materials and literature. The student could then use AI to generate template MATLAB code for a shooting method approach, which would likely require substantial debugging and modification to work correctly. An ideal final report would document this iterative process, explaining which AI suggestions were helpful and which were misleading.

**Problematic AI use pattern**: Conversely, a student might ask ChatGPT to solve the entire problem and submit code with minimal modifications. Such code could appear sophisticated but produce non-physical results (negative thrust magnitudes, energy violations). When questioned during an oral examination, this student might be unable to explain the optimization approach or identify why results were incorrect. This pattern illustrates how AI can generate plausible-looking but fundamentally flawed solutions for specialized problems.

These contrasting hypothetical cases reinforce the importance of assessment methods that probe understanding rather than merely accepting submitted work. Actual implementation of such assignments would require careful scaffolding and clear evaluation criteria to guide students toward the effective pattern.

## 5.3 Student Feedback and Course Evaluations

Student feedback played a crucial role in assessing the impact and effectiveness of the mini-course. When submitting their homework, students were asked to provide feedback on their learning experience, the course content, and the instructor's performance.

The feedback received was generally positive, with students expressing appreciation for the opportunity to learn about AI and its practical applications in aerospace engineering. Most students also appreciated the interactive nature of the course, which facilitated their understanding of the topics covered.

However, some students expressed disappointment with the performance of ChatGPT, noting that the AI-generated content was often superficial and lacked depth. This observation itself became a valuable learning outcome, as it demonstrated students' developing critical evaluation skills regarding AI outputs.

Students provided valuable suggestions for improving the course, including:

- Including more diverse case studies and examples to showcase a wider range of AI applications
- Incorporating more hands-on exercises during the session to enhance engagement
- Extending the course over multiple sessions to allow for a more comprehensive exploration of AI tools and their applications

The feedback received from students was carefully analyzed and used to inform future iterations of the course. The insights gained helped identify areas for improvement, such as refining the course pacing, developing additional support resources, and expanding the range of case studies and practical examples. These student responses suggest that while participants recognized the value of AI tools, they also understood the importance of critical evaluation and desired deeper engagement with the material.

# 6 Faculty Perspectives and Institutional Implementation

## 6.1 Faculty Development Session Outcomes

As shown in Table 1, faculty development sessions were delivered at multiple institutions. The sessions revealed diverse perspectives and concerns:

**Technical faculty concerns**:

- How to prevent AI-enabled plagiarism while allowing productive use
- Whether AI undermines development of problem-solving skills
- How to update decades-old assignments that AI can now solve trivially
- What computational/mathematical skills remain essential when AI can code

**Faculty enthusiasm areas**:

- Using AI to generate diverse problem sets and exam questions
- Automating creation of assessment rubrics
- Improving efficiency in responding to routine student questions
- Accelerating literature review for research
- Generating draft text for grant proposals and course materials

Quantitative feedback data is available from some sessions. A representative example is the Universidad de Valladolid workshop ($n = 36$), where participants rated aspects of the course on a 1–5 Likert scale. Results were strongly positive: general satisfaction received 91.6% ratings of 4 or 5 (mean 4.39); clarity of concepts, 97.2% (mean 4.50); understanding of AI limitations and risks, 94.4% (mean 4.56); relevance to professional work, 97.2% (mean 4.56); and usefulness of demonstrations and exercises, 91.6% (mean 4.50). Notably, participants' self-reported starting level in generative AI varied considerably (mean 3.14), confirming the value of sessions accessible to diverse experience levels. Similar feedback patterns were observed at other institutions, though not all sessions included structured surveys.

Several faculty reported significant productivity gains. One professor described using Claude to generate initial drafts of course syllabi, which reduced preparation time from several days to a few hours while maintaining quality after human review and customization. Another used ChatGPT to create variations of homework problems, helping prevent answer-sharing among students while testing the same underlying concepts.

## 6.2 Institutional Policy Considerations

Discussions with faculty and administration identified several institutional challenges:

**Policy uncertainty**: Most universities lack clear AI use policies for academic work. Faculty expressed frustration with ambiguous guidance that neither prohibits nor endorses AI use, leaving instructors to develop ad hoc approaches.

**Assessment redesign**: Traditional homework and exam formats require substantial revision when AI can solve routine problems. This represents considerable work for faculty with established course materials.

**Equity concerns**: AI tools often require paid subscriptions for best performance, potentially creating disadvantages for students without financial resources. Institutions must consider providing access to premium AI tools as part of educational infrastructure.

**Faculty training needs**: Most faculty lack formal training in AI capabilities and limitations. Professional development programs are essential for responsible institutional integration.

**Academic integrity frameworks**: Existing plagiarism policies were designed for a pre-AI era. Updated frameworks must distinguish between appropriate AI assistance and academic dishonesty while recognizing that these boundaries may differ across disciplines and assignment types.

## 6.3 Recommendations for Departmental Implementation

Based on multi-institutional experience, the following departmental-level actions are recommended:

- Develop explicit AI use policies that faculty can reference in syllabi
- Provide professional development opportunities for faculty

- Create repositories of AI-aware assignment designs and assessment strategies
- Establish departmental guidelines on acceptable AI use for different course levels
- Consider providing institutional access to premium AI tools
- Form faculty working groups to share experiences and best practices
- Revise academic integrity policies to address AI-specific scenarios

Implementation requires administrative support and resources, not just faculty initiative. Departments that treated AI integration as a strategic priority rather than an individual faculty concern demonstrated more coherent and effective adoption.

# 7 Long-Term Implications for GNC Education

## 7.1 Curriculum Evolution

The widespread availability of AI tools necessitates rethinking what skills and knowledge aerospace engineering curricula must develop:

**Enduring fundamentals**: Core concepts that remain essential regardless of AI capabilities include physical intuition, mathematical reasoning, approximation and scaling arguments, debugging and verification skills, and engineering judgment about feasibility and constraints. These represent what students must learn deeply, not merely access through AI.

**Evolving skills**: Competencies that change nature but remain important include coding (shifting from syntax memorization toward algorithm design and verification), technical writing (from grammar toward argument structure and persuasion), and calculation (from arithmetic toward interpretation and sanity-checking).

**New competencies**: Skills that become more important in an AI-augmented environment include prompt engineering for technical applications, critical evaluation of AI outputs, integration of AI tools into professional workflows, and understanding of AI capabilities and limitations.

**Potentially reduced emphasis**: Traditional skills that may warrant less instructional time include memorization of equations (when AI provides instant access), syntax-heavy programming instruction (when AI generates boilerplate code), and routine algebraic manipulation (when symbolic math tools and AI handle mechanics). However, understanding underlying concepts remains non-negotiable even when AI handles execution.

## 7.2 Assessment Strategy Transformation

AI availability fundamentally changes what can be effectively assessed through traditional homework and exams:

**Homework evolution**: Take-home assignments can no longer reliably assess individual problem-solving ability when AI can generate solutions. Responses include requiring documentation of solution process and AI use, focusing on analysis and interpretation rather than calculation, incorporating oral defense of submitted work, and designing multi-stage problems where later stages require understanding earlier results.

**Examination approaches**: In-person exams remain valuable for assessing core understanding without AI assistance. However, exam design should evolve to emphasize conceptual reasoning over computational mechanics, qualitative analysis alongside quantitative problem-solving, and explanation of trade-offs and engineering judgment.

**Project-based assessment**: Extended projects with AI assistance explicitly allowed offer opportunities to assess synthesis, critical evaluation, and professional communication. Clear rubrics distinguishing AI-assisted work from original contribution become essential.

**Portfolio approaches**: Semester-long portfolios documenting learning progression, including reflection on AI use, provide holistic assessment less vulnerable to AI-enabled shortcuts than individual assignments.

## 7.3 Professional Preparation

Perhaps most importantly, AI integration reflects the reality that aerospace engineering graduates will work in AI-augmented environments:

**Industry expectations**: Aerospace employers increasingly expect new engineers to leverage AI tools productively. Students who graduate without AI literacy face competitive disadvantages, much as students without programming skills faced disadvantages a generation earlier.

**Safety-critical considerations**: Aerospace applications often involve safety-critical systems where AI-generated errors could have catastrophic consequences. Education must instill appropriate caution and verification practices from the outset.

**Evolving roles**: AI may automate routine engineering tasks, shifting human engineers toward higher-level design, verification, and decision-making. Education should prepare students for these evolved responsibilities rather than focusing primarily on routine calculations and code implementation.

**Lifelong learning**: The rapid pace of AI development means current tools will be obsolete within years. More valuable than mastery of specific current tools is developing adaptability and learning strategies for new AI technologies as they emerge.

## 7.4 Research Implications

Beyond education, generative AI impacts aerospace engineering research:

- Accelerated literature review and hypothesis generation
- Code prototyping for simulation and analysis
- Technical writing and documentation efficiency
- Potential for AI-assisted algorithm design and optimization

However, research applications require even more rigorous verification than educational use, as flawed AI outputs could propagate through scientific literature. The GNC research community must develop standards and practices for responsible AI use in research contexts.

# 8 Conclusions

This paper has presented two years of practical experience integrating generative AI education into aerospace engineering curricula across multiple institutions. Several key findings emerge:

**Integration is inevitable**: Attempting to prohibit AI use is futile and potentially counterproductive. Students will use available tools regardless of policy. Effective education channels this usage productively rather than driving it underground.

**Guidance is essential**: Simply providing access to AI tools is insufficient. Students require explicit instruction on prompt engineering, verification practices, critical evaluation, and ethical use. The gap between high-performing and low-performing students in initial implementations demonstrated the value of structured guidance.

**Assessment must evolve**: Traditional homework and examination formats require substantial revision to remain effective in an AI-augmented environment. Assessment should evaluate understanding and judgment, not merely solution production.

**Faculty development matters**: Instructor comfort and competency with AI tools directly impacts quality of integration. Professional development programs should address both pedagogical strategies and practical AI literacy.

**Transparency reduces dishonesty**: Requiring documentation of AI use, rather than prohibiting it, normalizes these tools while maintaining academic integrity. Students demonstrate greater honesty when AI use is explicitly permitted with appropriate guidelines.

**Tools complement, not replace, fundamentals**: AI is most valuable when users possess strong foundational knowledge to guide its use and evaluate its outputs. Weakening fundamental education in favor of AI tool training would be counterproductive.

A limitation of this work is that the quantitative data remains modest in scale, and the findings should be interpreted as indicative rather than statistically generalizable. Larger, controlled studies with standardized assessment instruments would strengthen the evidence base. Nevertheless, the consistency of qualitative observations across diverse institutional and cultural contexts suggests that the identified patterns are robust.

The framework presented here—demystifying the technology, emphasizing verification, requiring transparency, and focusing assessment on understanding—provides a practical starting point for GNC educators navigating AI integration. Implementation will necessarily vary across institutional contexts, course levels, and specific learning objectives. However, the principles of responsible use, critical evaluation, and transparent documentation appear broadly applicable.

Looking forward, the aerospace engineering education community faces an ongoing challenge: how to prepare students for a professional environment where AI capabilities will continue evolving rapidly. Rather than treating current tools as endpoints, curricula should develop transferable skills including learning new technologies, evaluating claims critically, maintaining engineering judgment, and integrating tools thoughtfully into professional practice. These meta-competencies will serve students throughout careers spanning multiple generations of technological change.

The experience documented here suggests that thoughtful AI integration can enhance aerospace engineering education without compromising rigor or fundamental skill development. The key lies not in the technology itself, but in the pedagogical frameworks and institutional support that guide its use. As generative AI continues to evolve, ongoing collaboration among educators to share experiences, challenges, and effective practices will remain essential.

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# Declaration of Use of Artificial Intelligence

In keeping with the principles of transparency advocated throughout this paper, the author acknowledges that Claude (Anthropic) assisted in drafting and organizing portions of this manuscript. The irony of using AI to write about teaching AI use is not lost on the author. All pedagogical insights, course outcomes, and recommendations derive from direct implementation experience; the AI served primarily as a writing assistant and organizational tool. This declaration exemplifies the "transparency requirement" discussed in Section 3.1.

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