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Eagles Flight: A Curriculum Blend of Aviation, Engineering, and Industry Standards

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The work presented herein represents an ongoing study examining integrating industry standards into aviation and engineering curricula. Our goal is to provide insights into enhancing student preparedness for professional careers in aviation and engineering by analyzing the challenges and best practices in curriculum development. This National Institute of Standards and Technology (NIST)-funded project aims to bridge the gap between academia and industry. The research investigates the implementation of standards such as AS9100, ISO 31000, ISO 9001, ISO 14001, and ASHRAE 62.1 into three undergraduate and graduate engineering and aviation/aerospace courses. In this scholarly context, we investigate the preliminary developments and articulate the existing data-gathering techniques utilized in the pioneering aviation course initiated on August 24th, 2024, consisting of two sections with an aggregate of 50 students. Future work shall integrate initial findings obtained from a collection of surveys designed to assess the effectiveness of the standards-integrated curriculum related to the introductory module.

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Introduction

The rapidly evolving landscapes of aviation and engineering demand a workforce equipped with theoretical knowledge and practical skills aligned with industry standards. Our work investigates the crucial role of integrating industry standards into higher education curricula, focusing on a three-year project funded by the National Institute of Standards and Technology (NIST). We herein present preliminary data for work in progress, with data collection currently underway for the piloted classes implementing the standards-integrated curriculum. Our preliminary findings and methodologies will be refined and expanded as more data becomes available throughout the project.

Integrating industry standards into higher education curricula represents a critical strategy for enhancing the preparedness of students pursuing careers in aviation and engineering. This approach ensures that graduates comprehensively understand their respective fields' practical constraints and regulatory requirements. Integrating certification schemes into instructional design helps align educational programs with industry standards, improving employability (Aziz & Surono, 2024). Such knowledge significantly augments the value of graduates to potential employers by improving their workplace readiness and minimizing the necessity for extensive on-the-job training (Miller & Schademan, 2020; Patel et al., 2020). Developing a novel educational framework for the Maintenance, Repair, and Overhaul (MRO) sector underscores the importance of collaborative efforts between academic institutions and industry enterprises. This framework is designed to produce highly qualified graduates who meet the industry's evolving demands (Ichou & Veress, 2024). Furthermore, project-based learning models, which facilitate deep integration between industry and academia, have demonstrated remarkable efficacy in enhancing students' practical skills and innovation capabilities (Wang & Liu, 2024). This pedagogical approach effectively bridges the gap between academic theory and industry practice, equipping students with the necessary skills to operate within and extend existing regulatory frameworks. Implementing such models has shown promising results, with a recent study by the National Association of Colleges and Employers (NACE) reporting that 91% of employers prefer job candidates with work experience, and 65% favor candidates with relevant industry experience (NACE, 2024).

This ongoing project has the following aims: (1) Examine the role of standards in aviation and engineering education, (2) Analyze the implementation of specific standards (AS9100, ISO 31000; ISO 9001; ISO 14001, and ASHRAE 62.1) in curricula, (3) Present the challenges and best practices in integrating standards into higher education programs, (4) Evaluate the impact of standards-based education on student preparedness for professional careers, and (5) Assess student perceptions and learning outcomes through a series of surveys throughout each of the investigated courses.

The Role of Standards in Industry

Standards play a crucial role in ensuring safety, efficiency, and reliability across various sectors, yet they often remain unnoticed by the public and undervalued by decision-makers. These standards are essential for addressing global issues such as quality assurance, food safety, and environmental concerns, and they significantly influence innovation and competitiveness

(ANSI, 2024). Standards are benchmarks for quality and achievement across various fields, including aviation, engineering, science, technology, healthcare, and business. The National Institute of Standards and Technology (NIST) defines a standard as "a document that provides requirements, specifications, guidelines, or characteristics that can be used consistently to ensure that materials, products, processes, and services are fit for their purpose" (Breitenberg, 2009). Standards are crucial in aviation and engineering, ensuring safety, reliability, and operational efficiency while promoting product consistency. The importance of these standards extends beyond technical aspects, encompassing health, safety, and environmental (HSE) considerations in industrial operations. Employers highly value new graduates' knowledge of technical and HSE standards, recognizing their essential role in maintaining high-quality designs and processes (Crow, 2023). This comprehensive approach to standardization not only safeguards workers and protects the environment but also enhances overall operational resilience (Anaba et al., 2024).

The Gap Between Academia and Industry

Despite the well-recognized importance of industry standards, a significant gap often exists between academic curricula and industry requirements, as highlighted in numerous studies over the past decade. For instance, Lang et al. (1998) surveyed aerospace and defense companies and found that engineering curriculum reform needed to meet industry demands. This disconnect has important implications, including graduate employability, as those unfamiliar with industry standards may struggle in the job market (McPherson et al., 2019). Additionally, graduates without a strong foundation in standards often require extensive on-the-job training, affecting their initial productivity and placing added pressure on employers. Moreover, a lack of knowledge in this area can hinder their ability to innovate within regulatory frameworks, further emphasizing the need for alignment between education and industry expectations.

Description of the NIST-funded Project

Our research team has embarked on a three-year project funded by NIST to address this gap. This initiative endeavors to establish a replicable framework for integrating industry benchmarks within the curricula of engineering and aeronautics, with the primary aim of optimizing instructional modules. Our work aims to serve as a model for other STEM academic institutions and enhance educational outcomes at both undergraduate and graduate levels. Simultaneously, the long-term objectives of this project focus on fostering sustained collaboration and exchanging knowledge with colleges, universities, and industry stakeholders to refine the model curriculum and its educational effectiveness continuously.

The project focuses on five critical standards due to their widespread adoption in the aviation and engineering industries and their potential to provide students with a comprehensive understanding of quality, risk, and environmental management principles. These standards are:

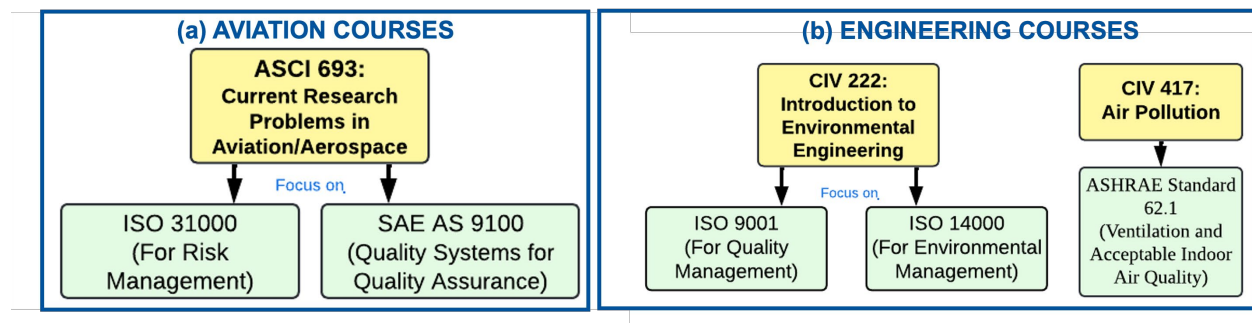
1. **AS9100:2016** Aviation quality management systems
2. **ISO 31000** Risk management
3. **ISO 9001:2015** Quality management systems
4. **ISO 14001:2015** Environmental Management systems
5. **ASHRAE 62.1** Ventilation and Acceptable Indoor Air Quality

Methodology

Our project employs a mixed methods approach to investigate the implementation of industry standards in aviation and engineering curricula. The research is being conducted as part of a three-year NIST-funded project to bridge the gap between academia and industry. Data is collected through student performance assessments pre- and post-implementation of standards-based curricula, semi-structured interviews with key stakeholders, and student surveys throughout each course. Three short surveys were administered within three modules of each investigated course. Each survey contains several multiple-choice choices with Likert scale questions and two open-ended questions. These surveys aim to capture students' perceptions, understanding, and application of industry standards at different course stages. In addition, the end-of-course evaluation includes additional questions related explicitly to integrating industry standards into the curriculum. The questions are designed to assess overall student satisfaction, perceived relevance to future careers, and areas for improvement. The Likert scale questions are designed to measure various aspects, including (1) Perceived relevance of standards to future careers, (2) Confidence in applying standards to real-world scenarios, (3) Understanding of specific standards (e.g., AS9100, ISO 31000; ISO 9001; ISO 14001, and ASHRAE 62.1), and (4) Satisfaction with the teaching methods used to convey standards-related content. The courses taking part in this project are presented in Figure 1.

Figure 1

A sketch showing the (a) aviation and (b) engineering courses participating in this project.



The open-ended questions enable students to provide detailed feedback, offer suggestions for improvement, and share examples of how they have applied the learning standards in course projects or internships. This survey approach allows for quantitative analysis of student perceptions and qualitative insights into the effectiveness of the standards-integrated curriculum. The data gathered from these surveys are instrumental in refining the curriculum and teaching methods as the project advances. While this research is ongoing, much of our current efforts are dedicated to data collection and preliminary analyses. We expect that the end-of-course evaluations will offer a comprehensive assessment of the program's effectiveness, particularly in determining the impact of the standards-integrated curriculum.

Some critical areas we plan to analyze include the correlation between exposure to standards and student performance in practical assessments, changes in student attitudes toward industry standards, and differences in learning outcomes between traditional and standards-integrated curricula. Additionally, critical areas of focus will be identifying the most effective

teaching methodologies for conveying standards-related content and understanding the long-term impact on career readiness and early career performance of graduates.

Preliminary Results

This section presents the preliminary results of a comprehensive survey conducted during the Fall 2024 semester for the ASCI 693 course. This advanced course, offered in two sections, enrolled 50 students. To gauge the effectiveness of our teaching methods and course content, we administered a focused survey to Classes 1 and 2. The survey was designed to capture student perceptions across four key course dimensions, providing valuable insights into the learning experience. By analyzing responses from both sections, we aim to identify variations in course delivery and student satisfaction and highlight areas of consistency in the educational experience. The results reveal interesting patterns and similarities between the two classes.

Table 1 summarizes the descriptive statistics of the first module's classes (Class 1 and Class 2), each with four questions from Q1 to Q4, with nine data points in each class. The mean values for both classes are 5.3 for all the questions, meaning that the answers are relatively similar between the two classes. Compared to Class 1, the standard deviation (stdev) has demonstrated that, on average, Class 2 is relatively more variably spread. Additionally, the values are more spread out for Q1 and Q2. The range between the minimum and maximum values shows the variability in the student's responses. Class 1 had a smaller range compared to Class 2. Further, the percentiles (25%, median=50%, and 75%) depict the data distribution relatively in the same pattern for both classes among the questions. The variation of responses is more significant in Class 2. However, their means are yet close to each other. These results are presented in Figure 2, where each boxplot shows a distribution rating, where the boxes represent the 25th to 75th percentiles, the orange line indicates the median of the datasets, and the whiskers show their range. Along the x-axis, the labels represent the ratings for each class on the respective questions; along the y-axis, the scale is used for ratings. The rating refers to the numerical scores assigned to questions answered by students. Figure 2 provides a visual assessment of the differences in ratings between the two classes for each question.

The remarkable response similarity between the two classes suggests a well-standardized course experience. This initial survey reveals a highly consistent and generally positive experience across both class sections, with some nuanced variations in specific areas. The uniformity in responses suggests effective teaching practices and course design that resonated similarly with students in both sections.

Table 1
A Comparative Analysis of Class Ratings Across Four Questions

	Q1		Q2		Q3		Q4	
	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2	Class 1	Class 2
Count	9	9	9	9	9	9	9	9
Mean	5.33	5.33	5.22	5.22	5.33	5.33	5.33	5.33
Stdev	0.71	1.22	1.09	1.09	0.71	0.71	0.71	0.71
Minimum	4	3	4	4	4	4	4	4
25th percentile	5	5	4	4	5	5	5	5
Median	5	6	5	5	5	5	5	5
75th percentile	6	6	6	6	6	6	6	6
Maximum	6	7	7	7	6	6	6	6

Figure 1
Comparison of student ratings between Class 1 and Class 2 for all questions.

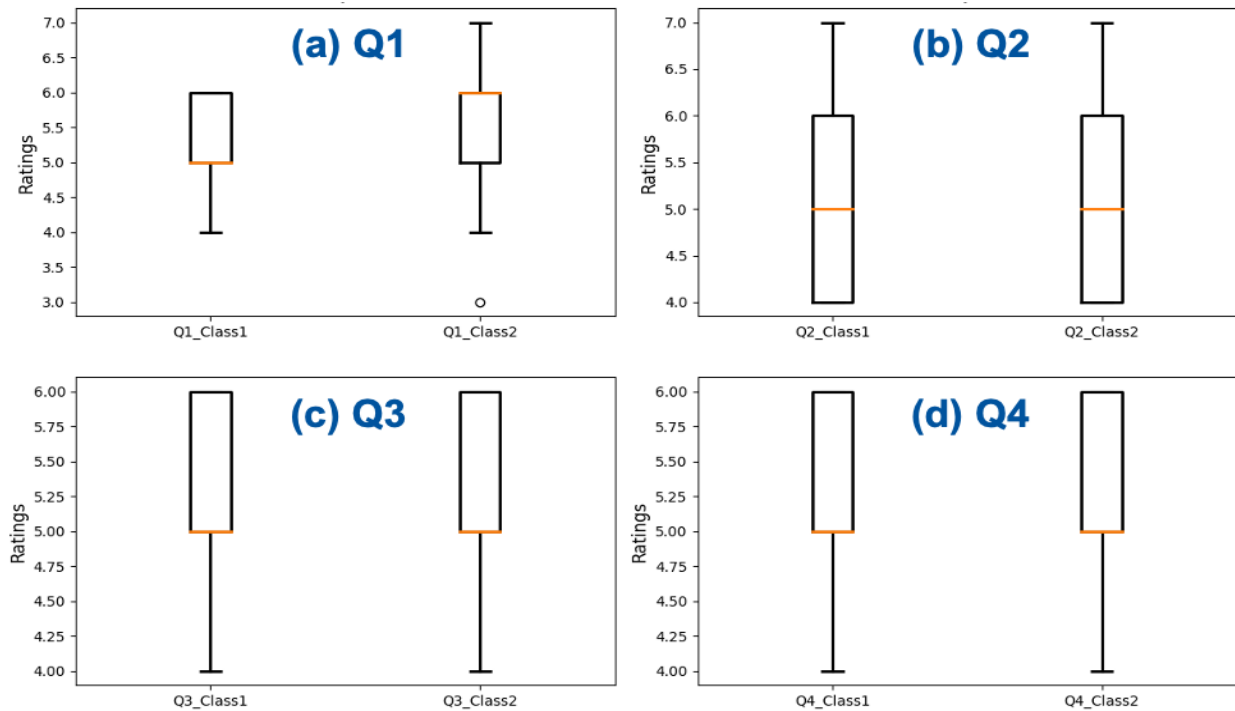
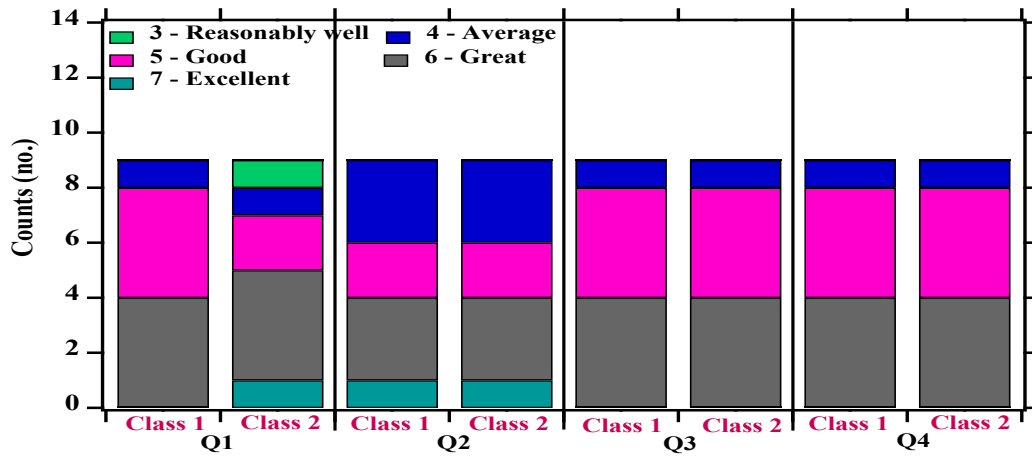


Figure 3 compares student responses from the two classes across the four survey questions. Student ratings ranged from "reasonably well" (3) to "excellent" (7), with no responses falling below three or exceeding 7. While the responses for questions 2 through 4 were similar between both classes, notable differences appeared in question 1. Class 2 exhibited a broader range of responses, from 3 to 7, whereas Class 1 responses were more concentrated, ranging only from 4 to 6.

Figure 3

A comparison of student response distributions across four survey questions.



The results of this survey reveal intriguing patterns and notable similarities between the two class sections, offering a nuanced understanding of the course's impact and effectiveness. These findings provide a snapshot of current student experiences and serve as a foundation for potential course refinements and enhancements in future semesters.

Challenges and Emerging Best Practices

As standards are integrated into curricula, challenges and best practices emerge. One of the critical challenges is balancing the depth of standards coverage with existing course material without overwhelming students. Another issue is ensuring that standards are consistently interpreted and applied across different courses and instructors, which can lead to varying levels of understanding. Additionally, maintaining student engagement, especially with material seen as dry or overly technical, requires thoughtful instructional methods and creative presentation styles. On the other hand, several best practices are also coming to light. These include utilizing real-world case studies and industry examples to highlight the practical application of standards, incorporating hands-on projects that require students to apply standards in simulated industry scenarios, and fostering collaboration between academic departments and industry partners to ensure the curriculum stays relevant. These observations will be further refined as ongoing surveys and assessments provide more data.

Conclusions and Future Directions

As this research is ongoing, we focus on data collection and preliminary analysis. We anticipate that the three short surveys embedded within the course modules will provide valuable insights into students' evolving perceptions and understanding of industry standards. As we investigate these surveys more thoroughly, the complexities of integrating these standards into higher education curricula are becoming increasingly apparent. However, early results are encouraging, suggesting this approach could significantly enhance student preparedness for professional careers in aviation and engineering. Despite the positive findings, challenges such as content overload and assessment complexities indicate the need for continuous refinement. A

global perspective on standards education emphasizes its universal importance and shows diverse approaches that can inform our methodologies. As industries evolve, so must our strategies for preparing students for future challenges, with areas like AI, sustainability, and international harmonization shaping the future of standards education.

In conclusion, while this study remains a work in progress, initial findings highlight the value of integrating standards into higher education. Ongoing data collection and analysis will further shape our understanding and potentially reshape how academia and industry collaborate. Several areas for future research have emerged, including longitudinal studies to track graduate outcomes, expanding this approach to other disciplines, developing standardized curriculum modules for broader use, and fostering industry partnerships to ensure that students gain real-world experience with standards implementation.

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