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Achieving and sustaining an active learning environment for large student enrollment classes in the Aviation and Engineering Technology Program.

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Abstract

This research paper aims to explore strategies, challenges, and sustainability considerations for establishing and maintaining an active learning environment using innovative pedagogy within a rapidly expanding aviation and engineering technology program at a minority-serving institution. The challenges and results of maintaining an active learning environment in both large-enrollment lectures and laboratories are explored. The study employs both quantitative and qualitative research methodologies. Quantitative data uses analysis of past student enrollment and attendance trends over the past five years to provide an understanding of the program's growth. Qualitative methods use classroom observations and student surveys from current students enrolled in the class and the instructors. These qualitative methods provide valuable insights into the experiential aspects of the learning environment for instructors. Through this comprehensive investigation, the study aims to contribute to the development of innovative pedagogical strategies for active learning in higher education, particularly in large-enrollment classes and programs. Survey and observation results showed that a majority of students found active learning activities beneficial to the learning environment, despite large course enrollments of over 30 students per section. Notable results included continued growth in courses, student feedback highlighting the benefits of active learning, and active learning activities conducted in class. In addition, students did not find that the traditional classroom layout affected active learning for Aviation and Engineering Technology courses.

Introduction

Active learning pedagogy is characterized by student-centered learning, where the class values student participation and engagement. This instructional style has been widely adopted in engineering education to promote student engagement [1]. However, scaling active learning practices in large-enrollment environments, particularly in laboratory-intensive aviation and engineering technology programs, has become a major challenge [2]. Limited classroom and laboratory allocations due to shared spaces across multiple classes further constrain active learning, leaving only expanding the number of classes as the solution to support increased enrollment. Traditional classroom discussion and in-class activities in large-enrollment classes often result in limited student participation, as only a small proportion consistently engage due to peer pressure, social dynamics, language barriers, or fear of negative judgment for incorrect answers [3]. A lack of interest or perceived relevance of the material may further reduce students' motivation to contribute. Another contributing factor is that classroom discussions are often dominated by a few students who are known to be more confident and outgoing. Consequently, traditional instructional approaches may fail to foster inclusive and equitable participation, limiting opportunities for meaningful engagement and involvement among all learners [4]. Structured cooperative learning has been shown to increase individual accountability and reduce social loafing when clear responsibilities are assigned [5]. Active learning increases student performance in science, engineering, and mathematics [6].

Higher education across the US has experienced varying enrollment trends over the past five years due to budget constraints, online education, and workforce demand. However, student enrollment at the San Jose State University Aviation and Engineering Technology program has increased significantly over a short period. Student enrollment has increased from 202 in 2015 to 471 in 2025, a 133% increase over ten years. Figure 1 shows the total growth of the Aviation and Engineering Technology students over the past ten years. Multiple factors have driven the increase, including workforce needs, industry partnerships, and the promise of career-aligned education. As a minority-serving institution, this growth has presented the department with opportunities for expansion and additional funding, as well as challenges, such as maintaining access to core program courses for students and ensuring instructional quality and equity in increasingly large classrooms. The aviation educational environment traditionally focuses on a set of key values, such as small-scale training environments, low instructor-to-student ratios, hands-on teaching materials, and active learning in classroom and laboratory instruction. This study focuses on three core program courses that all aviation degree tracks are required to enroll in to meet graduation requirements. Two of the courses are taught in a lecture-only format. The third course contains a lecture section and a required laboratory section in which students practice hands-on work on actual aircraft components. These three classes were selected for the study to provide a representative view of instructional practices across differing course structures and to allow for a comparative analysis of active learning implementation in both lecture-only and lecture-laboratory environments.

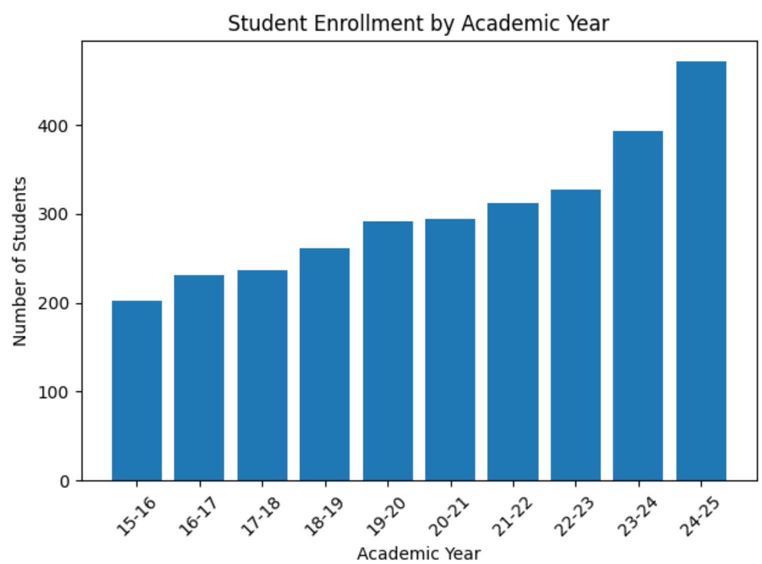

Figure 1: Enrollment trend in Aviation and Engineering Technology students over 10 years.

Research Design

This study employed a mixed-methods research design, integrating quantitative and qualitative approaches to provide a comprehensive understanding of instructional dynamics within a rapidly growing aviation program. Three classes were selected for the study. All three classes are part of the core curriculum, and all students must enroll and pass the courses to graduate. Two classes are lecture-only, while one class has a lecture and a laboratory component. The two-lecture classes are upper-division courses intended for students in their Junior or Senior year. The third course is a lower-division course expected to be completed in the student's sophomore year. The enrollment trends for the classes are shown in Table 1. The three classes selected for the studies were:

- Aviation Safety and Security - Upper Division – Lecture only
- Human Factors in Aviation - Upper Division – Lecture only
- Avionics/Airborne Communication - Lower Division – Lecture and laboratory

Table 1: Student enrollment in the past 5 semesters

Class/Term	Spring 2023	Fall 2023	Spring 2024	Fall 2024	Spring 2025
Aviation Safety and Security	30	40	45	63	75
Human Factors in Aviation	26	28	30	34	67
Avionics/Airborne Communication	35	27	30	60	68

For this study, a large-enrollment student class is defined as one with more than 30 students enrolled in the major-specific course. All three classes were classified as large-enrollment, major-specific courses. An anonymous survey was sent to students in all three courses, containing both qualitative and quantitative questions. Table 2 shows the number of students per class, the number of returned surveys, and the survey completion rate. In all three classes, the survey was given as an extra credit opportunity to the students. The surveys were sent to students at the end of the semester's final lecture. In addition to the questions, the following demographic information was collected from students:

- Students' current classification (Freshman, Sophomore, Junior, Senior)
- The students' current major at the time of enrollment.
- Students estimated attendance at the class (always, often, sometimes, rarely)

Table 2: Student Enrollment and Survey Response Rate

	Students Enrolled	Surveys returned	Return percentage
Aviation Safety and Security	71	69	97.2%
Human Factors in Aviation	61	54	88.5%
Avionics/Airborne Communication	34	29	85.3%

In addition to the categorical information, each student was asked to respond to the question on a scale from 1 to 5, with 1 indicating strongly disagree and 5 indicating strongly agree. Question 11 was given to students as a free-response question. The following questions were listed on the survey.

1. The class and lab activities help me connect theory to practice.
2. The physical layout of this classroom encourages student interaction.
3. The instructor uses in-class activities to check our understanding
4. Time spent on active learning activities is used effectively in this class.
5. I feel comfortable sharing my ideas during class activities.
6. During class, I mostly listen passively rather than participate
7. I have frequent opportunities to work with classmates during class.
8. Active learning activities help me understand course concepts more deeply.
9. This classroom environment helps me develop problem-solving skills.
10. This classroom environment helps me develop communication skills.
11. What do you think was the most beneficial active learning activity in this course?

Results

The survey results further underscore the importance of innovative pedagogical design in large classrooms. Approximately 95% of students indicated a preference for a more active learning environment that incorporates various in-class activities, rather than a traditional lecture format centered on passive information delivery. Students not only recognize the value of engagement-based strategies but also actively desire instructional approaches that promote participation and interaction with their peers in the classroom.

Four notable results are presented. These four were selected as they appear to have the most impact on assessment and department planning moving forward. First, because many students taking the lower-division course were enrolled later than planned due to classroom and laboratory space limitations, only a single sophomore was enrolled as planned, compared to the degree roadmaps. The Avionics class is limited in capacity due to challenges in sharing the laboratory area among 4 other courses. Because the avionics class was taken later than planned, multiple students noted that it would have benefited their learning more had it been taken earlier in their academic career. Human Factors and Aviation Safety both had the expected enrollment distribution, as the courses are typically taken during the Junior or Senior year of the degree.

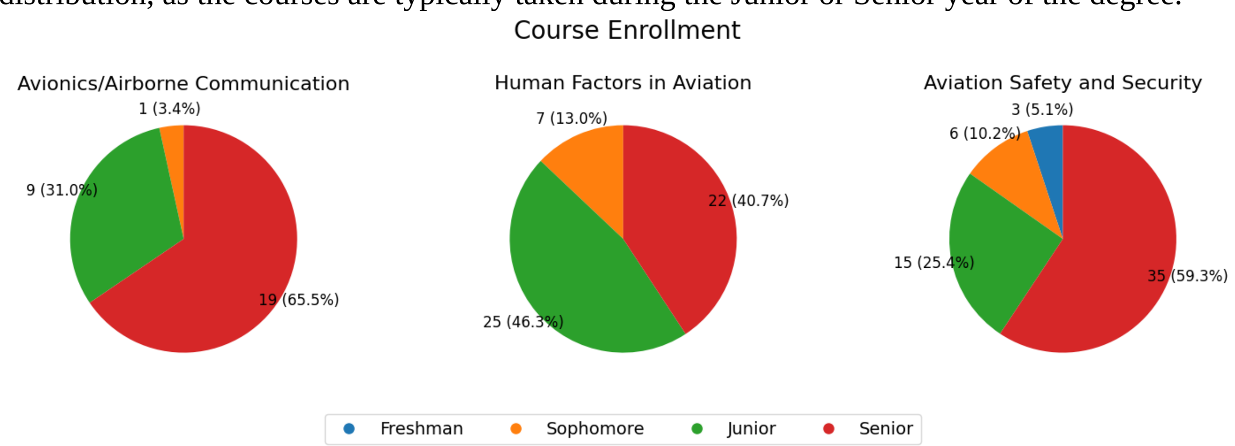

Figure 2: Enrollment distribution and classification of each student

The second notable result is from question 2 regarding the room layouts. The three classes were each hosted in a different classroom, with Avionics hosted in a different room for lecture and laboratory. All three lecture classrooms have a traditional layout with all desks facing the instructor podium/projector screens. The laboratory room uses lab tables, with groups of 4 students facing each other to complete the weekly lab task. The overall results of question 2 are shown in Figure 3. The survey showed that students did not find any issues with the traditional layout compared to classrooms with a more active-learning layout. For the avionics class, this could be due to the laboratory section starting immediately after the lecture.

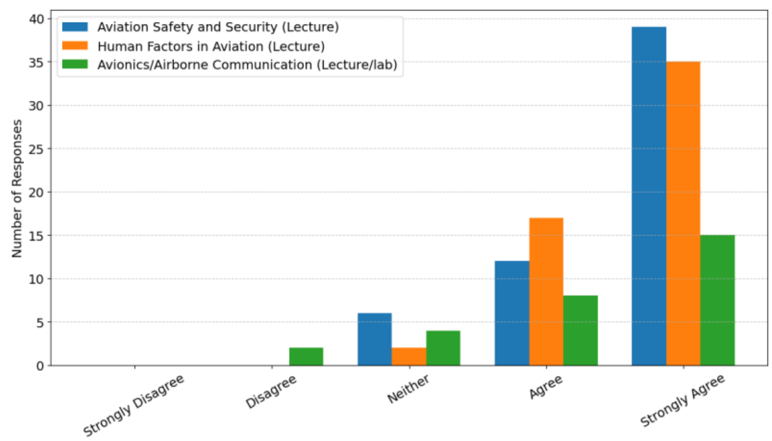

Figure 3: Student responses to question 2: "The physical layout of this classroom encourages student interaction."

The third result showed that students viewed in-class activities as a way to monitor and assess learning. The results were skewed towards strongly agree; however, the other responses were evenly distributed, as shown in Figure 4. Overall, the results show that active learning activities in the classroom can be used to check student understanding of the course material. In addition, all three classes also use non-active learning methods to evaluate the students, such as exams and quizzes. While the survey was stated to focus on active learning elements, the responses to question 11 indicate that some students may have completed the survey based on all evaluation methods, not just the active learning activities.

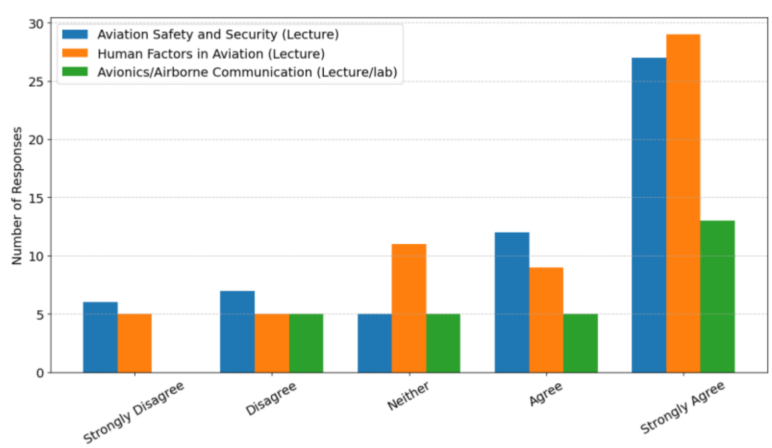

Figure 4: Student responses to question 3: "The instructor uses in-class activities to check our understanding."

The fourth notable result from the survey showed that students found the active learning activities aided their understanding of the course material. Question 8 responses were less skewed than those for other questions, showing that while the majority of students agreed that active learning aided them, they felt less strongly about the impact of the active learning activities on the course material than in the other questions.

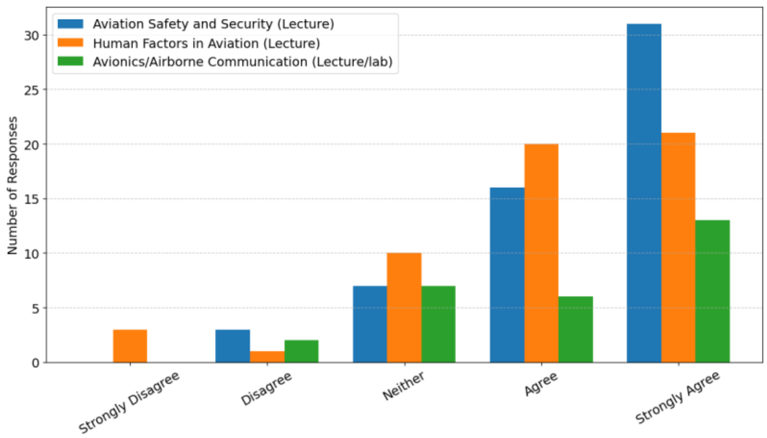

Figure 5: Student responses to question 8: "Active learning activities help me understand course concepts more deeply.

Multiple active-learning strategies have been used across all three courses, including Think–Pair–Share, flipped classrooms, paper airplanes, audience response systems (ARS), group discussions, and debates. For the active learning activities, not all are used across the three classes or used equally throughout the semester. Students in the free-response question repeatedly highlighted two activities as having a particularly significant impact. In Aviation Safety and Security and Human Factors in Aviation, students consistently cited the paper airplane activity as an effective active-learning experience. Students found the paper airplane activity beneficial and engaging, as it involved analyzing scenarios, sharing anonymous opinions, and discussing different perspectives as a group. In Avionics and Communications, students frequently emphasized the use of the Audience Response System (ARS), commonly known as Kahoot quizzes. Students described the weekly or lecture-based quizzes as beneficial for reviewing material and checking understanding.

The Paper Airplane Activity

The paper airplane activity is designed to engage all students while preserving anonymity, thereby reducing the fear of public judgment. Each student within a group is assigned a specific role: writer, engineer, speaker, or pilot. Groups receive a physical handout containing a scenario-based question intended to promote critical thinking and discussion. After roles are assigned, groups are given 5 minutes to analyze the scenario, decide (go or no-go), and develop a clear justification. The writer records the group's response on the handout and passes it to the engineer, who folds the paper into a paper airplane. At the instructor's direction, the designated pilot from

each group stands and throws the airplane across the classroom. Each group then retrieves a randomly received, anonymous airplane from another group. During the reporting phase, the speaker reads aloud the decision and justification written by the other group.
This structured, anonymous opinion-exchange activity offers several pedagogical benefits that promote full-class participation and engagement. The use of assigned roles ensures equitable involvement among group members. By designating specific responsibilities, writer, engineer, pilot, and speaker, every student is required to contribute, minimizing passive participation and fostering accountability within the group. Due to differing opinions and backgrounds, a group of students may have viewpoints that can be shared without feeling the need to conform to the group consensus.

Audience Response System (ARS) / Kahoot Quizzes

Student feedback also suggests that the Audience Response System (ARS), often implemented through Kahoot quizzes, functioned effectively as an active learning strategy. These quizzes align with established principles of retrieval practice and formative assessment, both of which are strongly supported in higher education pedagogy [7]. By requiring students to recall information rather than passively re-read or listen actively, ARS-based quizzes promote deeper cognitive processing and strengthen long-term retention. When implemented as interactive polling tools, they also provide immediate feedback, enabling students to identify gaps in their understanding in real time. Beyond content review, lecture-based quizzes support metacognitive development by encouraging students to monitor and evaluate their own learning progress. When students perceive quizzes as opportunities to "check understanding," they are engaging in self-assessment, a core component of self-regulated learning.

Conclusion/Future Work

This study examined the implementation and sustainability of active learning strategies within large-enrollment aviation courses at a minority-serving institution. Despite significant program growth and increasing class sizes, the findings demonstrate that active learning can be effectively maintained in both lecture-only and lecture/laboratory environments. Student feedback consistently indicated that active learning activities enhanced engagement, supported deeper understanding of course material, and provided meaningful opportunities for participation.
Several key insights emerged from this study. First, active learning strategies such as structured group work, anonymous participation activities (e.g., the paper airplane exercise), and audience response systems (ARS). Second, the physical classroom layout was found to be less influential than instructional design, suggesting that effective pedagogy can overcome spatial limitations. Third, while active learning was broadly viewed as beneficial, variations in perceived impact indicate opportunities to refine these approaches further to maximize learning outcomes.

Future work should focus on several areas to build upon these findings. Longitudinal studies are needed to evaluate the impact of active learning on student performance, retention, and career readiness over time. Expanding the study across additional courses would improve generalizability and provide comparative insights. Further research should also explore optimization of specific active learning techniques, including how different strategies align with course level, class size, and student demographics. Addressing structural challenges, such as laboratory capacity and course scheduling, will be critical to ensuring timely access to key courses and maximizing their educational impact.

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