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Incorporating Narrative Non-Fiction Reading into an Aerospace Engineering Course

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Abstract

Most aerospace engineering textbooks include historical anecdotes designed to teach the student about the history of aerospace engineering, but textbooks are typically expository in nature and may not effectively engage and motivate students. This paper describes the incorporation of narrative non-fiction reading about aerospace history into an Introduction to Aerospace Engineering course for upper-level general engineering students. The project had three objectives: to apply the course material to a historical aerospace application, to encourage students to explore the societal and historical context of aerospace engineering, and to foster a desire for lifelong learning in engineering students. Each student (N = 16) selected a narrative non-fiction book about aerospace history from a curated list of titles available at the campus library in physical or electronic form. After reading their book, students wrote a short book review, answered reflection questions about the intersection of society and aerospace technology, and gave a short presentation to the class in which they related concepts taught in the course (aircraft top speed, aircraft range, orbital mechanics, etc.) to the content of their book. Analysis of the change in response between pre- and post-project questionnaires showed that students gained a better understanding of the historical and societal context of aerospace engineering and were inspired to continue learning about aerospace history. These results suggest that narrative non-fiction reading can be used to provide the historical and societal context of technological innovation in aerospace engineering in a way that captures students' interest and sparks the desire for further learning.

Introduction

The history of aerospace engineering is a testament to human ingenuity and progress; this history offers important lessons that can shape the thinking and creativity of future aerospace engineers. Incorporating history into engineering courses can help students contextualize engineering practice [1] and establish themselves as problem solvers who work within a particular set of constraints and opportunities [2]. Understanding the history of a field also sets the starting point for future progress; Ryan [3] notes at the end of their NASA technical report: "Lessons from the past contain the keys to the future, if used appropriately."

Yet – studying history does not always come naturally for engineering students. At the beginning of the Fall 2024 semester, students in Introduction to Aerospace Engineering at the University of Mary Hardin-Baylor (UMHB) were asked to read the first chapter of the course textbook, John Anderson's *Introduction to Flight* [4], before class the following week. The chapter discussed the history of flying machines, from da Vinci's drawings through modern-day airplanes. The text is engaging and well-written, with pictures and charts to set the historical context for the remainder of the book. The first chapter of Anderson's textbook, while it does include several

short narratives, is largely expository. Many students came to the next class disgruntled, commenting that the reading was challenging. The students averaged a 75/100 on the reading quiz for the chapter, and none appeared energized by the reading. This begs the question: what is a better way for students to be excited about (and understand) the history of aerospace engineering?

Hidi and Renninger [5] explain how interest is developed, from an initial interest in a topic to a lasting, self-motivated interest that persists beyond the classroom and results in further learning. They propose that this interest must first be accompanied by positive feelings about the topic – something the students in this course did not initially have, based on their feedback about the textbook's first chapter. Since Hidi and Renninger claim that negative feelings about a topic will not encourage further interest in learning, those initial negative feelings needed to be reversed and positive feelings about the history of aerospace engineering needed to be developed. They also propose that learners need to find value in a topic before interest can develop. The intent of this paper's authors was to kindle those positive feelings and teach the value of the knowledge of aerospace engineering history through the reading of narrative (or creative) non-fiction books.

Presenting history through narrative has several potential benefits for students. In general, narrative texts lead to better recall and content understanding than expository texts [6]. Dahlstrom [7] showed how narrative can help non-experts relate to scientific concepts; this suggests narrative non-fiction about aerospace history can help non-experts (students) relate to technical course content. Narrative non-fiction also allows the reader to consider a broader story, incorporating context that could otherwise be lost. Engineering occurs within a social and historical context [8], and narratives can help learners form complex connections between technical and non-technical content. For example: Halada and Khost [9] used narrative short stories and case studies to encourage student reflection on the interactions between engineering, technology and society. Finally, narratives put humans at the center of the story, instead of technical content. Stolk and Martello [10] showed that integrating a human-centered approach into their course project increased student motivation and encouraged higher use of critical thinking. All of this supports ABET student outcome #4: "an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" [11], which needs to be consciously reinforced throughout an engineering curriculum [12].

This paper describes the implementation of a book project into an upper-level aerospace engineering course for general engineering students. The students were asked to select a narrative non-fiction book about aerospace history, write a short report, and present their findings to the class. The objectives of the project were to help students apply the course material to a historical context, to promote students' lifelong learning through reading, and to encourage students to explore the societal and historical context of aerospace engineering. The following

sections describe the methodology, the project implementation, and project outcomes (as assessed through pre-project and post-project questionnaires.)

Methodology

Providing engineering students with historical context is not a novel idea and can take several forms. One model is to create interdisciplinary (or cross-disciplinary) history/science/engineering courses. For example, Genau and Millard [13] describe a history class co-taught by a history professor and engineering professor, and Kett [14] describes a history of science and technology class for engineering students. Another common approach is to incorporate case studies [9], [15] [16], which give students an in-depth view of a particular event but are typically expository rather than narrative.

There are several examples of instructors incorporating narrative history into engineering classes, all with positive results. Ma and Tao [17] infused historical figures (mathematicians, scientists, engineers) into two junior level engineering courses (fluid mechanics, machine design); the historical content "positively affected student engagement and retention of basic principles, as well as enhancing their interest in learning the topics." Biezad [18] incorporated biographies of philosophers and mathematicians into an engineering ethics course, which helped students both appreciate and understand ethics. Cornwell [19] incorporated historical biographies into a dynamics course, which helped students engage with the course material. Stolk and Martello [20] tied history and materials science together through a three-course sequence centered around Paul Revere, leading to positive impacts on student perception of learning and student motivation.

In one additional example, Willis and Conrad [21] incorporated historical context by teaching celestial mechanics and heat transfer through the lens of the seminal scientists in their fields, such as Newton and Fourier. They offer the following conclusion in their paper:

> *"While the student feedback supports the idea that historical context allows students to better understand why they are learning a given topic, it is not clear that they learn that topic better or are motivated to be more interested in the topic after being made aware of the history behind the concepts. More data and analysis of that data is necessary to show that this is the case for this interdisciplinary course."*

This quote highlights a challenge with incorporating historical content into an engineering course. Willis and Conrad note the same three goals that were presented in the introduction (historical context, learning technical content and promoting student interest/lifelong learning), but only reference a measurable effect on one of these goals. The authors took this into consideration when designing the book project for Introduction to Aerospace Engineering.

There are fewer examples in the literature of engineering courses requiring students to read non-fiction books as a course supplement. Murray and Raper [22] used a non-fiction business

management book to encourage lifelong learning in engineering management students (with encouraging, but mixed, results). Rossman and Roth [23] describe how students at their university read a non-fiction book (*Warmth Disperses and Time Passes* by Hans Christian von Baeyer [24]) as a supplemental text in their thermodynamics course. In [25] students in an introductory engineering course were assigned short stories and chapters from philosophical texts with the goal to "develop the mindsets and skills of well-rounded engineering students through thoughtful liberal arts reading." Another example is described by Mavriplis [26]; they had students in their introductory course read a non-fiction narrative about adventures (such as deep sea operations [27], balloon flight [28] or space flight [29]), which was tied into a central course theme: "pressure." Reading one of the books (while discussing the other two books with classmates) further motivated students to study mechanical engineering. This study played a significant role in shaping the current work in two important ways. First, the authors aimed to create a diverse list of books on aerospace history, giving students the freedom to select one based on their interests. Second, students were given the opportunity to share the content of their book with the class, so the entire class would learn about aerospace history through multiple narrative perspectives.

Project Implementation

The project was implemented in an upper-level elective for general engineering students. UMHB offers a general engineering degree, with specializations in either Mechanical or Electrical Engineering. Introduction to Aerospace Engineering is available to students focusing in either discipline, but the course was designed with Mechanical Engineering students in mind [30]. The course pre-requisites are Thermodynamics and Dynamics, which serve as the foundation for discussions on Aerodynamics and Aircraft Stability/Control, respectively. The textbook for the class was *Introduction to Flight* by Anderson and Bowden [4], and the course content was split into six modules: the standard atmosphere, aerodynamics, aircraft performance, aircraft stability and control, astronautics, and propulsion (which follows chapters 2 through 7 of the textbook).

Due to the untimely passing of a mathematics professor the week before the semester started, five mathematics students enrolled in the class as a substitute for an upper-level mathematics elective. Because these five students did not complete the course pre-requisites, additional class time was spent covering background material as needed. Table 1 shows a demographic breakdown of the students in Introduction to Aerospace Engineering for the Fall 2024 semester.

Table 1: Demographic Statistics for Introduction to Aerospace Engineering (Fall 2024)

Gender	15 Male, 1 Female
Major	9 Mechanical Engineering, 5 Mathematics, 2 Electrical Engineering
Class Year	9 Seniors, 7 Juniors

The book project counted for 15% of the final course grade. The project was broken down into four assignments, shown in Table 2.

Table 2: Breakdown of Assignments for the Book Project

Assignment	Weight
Book Selection	10%
Short Answer Questions	25%
Book Review	25%
Class Presentation	40%

In the first assignment, students were introduced to the project and asked to pick a narrative non-fiction book about aerospace history or aerospace engineering. Students could select any book they had not previously read that was on-topic, and all selections were approved by the instructor. This also ensured that each student was reading a distinct book.

As a starting point for book selection, students were encouraged to peruse a book list created by the co-authors (instructor and librarian). The book list was available to students on a LibGuide (a type of modular content platform) hosted on the library's website [31]. The authors collaborated to create a diverse list of books to encourage student curiosity.

The course instructor initially created a list of non-fiction aerospace history books with personal familiarity. Then, the course instructor added additional books to increase the diversity of the list (specifically targeting groups that were not well represented in the initial list, such as narratives about women). This initial list was then split into two categories by the librarian – books that were already available in the library's holdings and books that were to be considered for purchase in print format. Print books that were not in the collection were searched for in the library's electronic holdings, and any titles that were found to be available in ebook format were moved to the list of books already available. The remaining list of books were individually considered for purchase according to the library's collection development policy, which is based on the guidelines for selection published by the American Library Association [32]. The books that met the selection criteria were purchased in print format and added to the library's collection. Those titles, along with the print titles selected by the instructor that were already in the library's holdings, comprised the list of print books provided to the students to choose from (see Appendix A).

The next step was developing a list of narrative nonfiction ebooks that the library had in their holdings. STEM students have shown a preference for ebooks over print books [33], and students find ebooks convenient and easy to access [34]. Most importantly, ebooks are accessible to patrons with disabilities. The ebook platform used by the library, Adobe Digital Editions, is compatible with screen readers [35]. Providing accessible reading material to patrons is one of the priorities of libraries [36] since it is part of providing reading material for "all people of the community the library serves" [37]. Computers were available in the library that students could

use to read ebooks if they did not own a computer or mobile device, permitting equity of access of electronic books to students [38].

The list intentionally included diverse authors and characters since book collections (and book lists) are meant for a diverse readership [39], [40]. Books are to be "mirrors, windows, and sliding glass doors" for readers [41], offering a reflection of the reader or allowing them to see the experiences and lives of people that are not like them. The inclusion of books by and about underrepresented minorities in engineering also supports the ASEE in their statement that "we learn from experiences, beliefs, and perspectives that are different than our own" [42].

The final criteria used to select ebooks for the list was whether it appeared to be an engaging read. If a book's synopsis and introduction did not spark interest in further reading, it was removed from the list. Achieving the goal of creating interest in further reading on aerospace history was more likely to happen if the students read the books in the first place. The ebooks that met the above criteria, along with the titles selected by the instructor that were already in the library's electronic holdings, made up the list of ebook titles the students could choose from (see Appendix A).

Once students selected and read their book, they responded to set a of reflection questions (shown below). Students were asked to respond to each question with 2-4 complete sentences.

- How did the content of your book relate to a concept (or concepts) that we discussed in class?
- How did you observe society being influenced by aerospace technology in your book?
- How did you observe aerospace technology being influenced by society in your book?
- How did the characters in your book interact with the social and/or ethical implications of aerospace technology?
- What was the most interesting fact/concept you learned from your book?
- After reading your book: what topic, concept, or person in the history of aerospace engineering are you interested in learning more about, and why?

These questions were chosen to directly support the learning objectives outlined in the introduction. Many students noted that they were surprised by the connections between society and the aerospace technology in their book. The following responses were from a student who read *Hidden Figures* by Margot Lee Shetterly [43]:

- *A lot of the mathematical concepts that were covered in the book were above my paygrade in terms of understanding, but it was interesting to read about the use of Euler's Method to numerically solve differential equations that were used to send John Glenn into space. Being that we are just beginning to talk about astronautics, I completely understand that a lot of the concepts that were discussed in the book are going to go over my head. Reading about Mary Jackson and her work in the Supersonic Pressure Tunnel was very*

interesting because of how many times we discussed wind tunnels in class, and reading about how integral they are to aerospace engineering was also extremely interesting.

- *Obviously, with aerospace engineering being such an important role in the Space Race in the late 1950's and early 1960's, society was being impacted by whether or not we were going to beat the Russians into space. Another major application of aerospace technology and society is how invested the entire world was in the successful and safe launch of John Glenn into space, which reignited the faith in American engineering. Society was eager to see the Americans succeed at putting a man into space and returning him safely.*
- *The opposite is also true, as aerospace technology had been directly impacted by growing national concern that the Russians were going to have a leg up in the technological realm. As soon as the Russians were able to launch Sputnik 1 into space in 1957, NASA had become an area of focus for society, as everyone wanted to help contribute to the Space Race. Aerospace technology also changed when the focus went from putting a man in space to putting a man on the moon, and society influenced that shift as well.*
- *All four major characters in the book overcame major racial and sexual barriers to be able to be a part of the growing aerospace field. Being able to be a part of such an important and high level field was extremely important to all of the characters. They were able to move through the ranks of NASA that was made up of employees that were predominantly white males, and make a name for themselves in the history of the administration.*
- *I think the most interesting fact that I learned, being a math major, was the numerical approach to solving differential equations using Euler's method. I read a lot about mathematics, and obviously I have heard of Euler before, but after reading this book, I read a lot about what Euler's method is and how it is applied. I also really thought this was interesting because of the fact that I am taking a Numerical Analysis course this semester, so seeing another application of a higher level numerical approach was extremely interesting.*
- *I realized that in reading this book, engineering may be something that I want to look into pursuing more. I think that aerospace engineering has opened my eyes to using my mathematical ability for something as important as NASA or something equivalent. I definitely want to research more about the mathematical side to the Space Race, and how the development of machine computing changed the way that NASA does its research now.*

The reflection questions allowed this student to reflect on the interactions of race, gender, nationalism, mathematics and aerospace engineering at NASA in the 1960s.

Students were also asked to write a 400–600-word summary of their book. The goal of this assignment was for students to summarize their book while continuing to reflect on the interactions between aerospace technology and society. The assignment description asked students to include the following information:

1) An Introduction: Briefly introduce the book, including the title, author, and the main theme or subject matter.
2) Key Events/Characters: Who were the main figures in the narrative, and how did they contribute to the story? What were the most important moments in the book?
3) Themes and Messages: Discuss the overarching themes of the book. What insights does the author provide through the narrative?
4) Conclusion: Reflect on the impact of the book. What did you learn from the book, and how does it relate to real-life experiences or broader societal issues?

A large language model (LLM) "trap" was also placed in the assignment description, to deter students from directly copying and pasting the prompt into an AI program. The trap was hidden text (font size 1), instructing the student to include several keywords in their submission. Several students caught the trap before the assignment was due, which led to a productive class discussion about LLMs and the purpose of the assignment. Students were invited to think about writing as "thinking," and use the assignment as an opportunity to process what they learned. Students were specifically discouraged from using an LLM to generate their book summary. Despite this discussion, the authors estimate that at least two of the sixteen students submitted a review solely authored by an LLM. A typical response from a student is shown below:

> *"The title of the book I chose for this project is Tuskegee Airman-The Biography of Charles E. McGee, written by his daughter, Charlene Smith-McGee. This biography offers a unique perspective of one of the greatest United States Air Force pilots of all time, Colonel Charles McGee. The book starts in Charles' early years, growing up during the Great Depression and encountering moderate amounts of racism where he lived. His dad, an African Methodist Church pastor, changed locations often and therefore let Charles and his siblings stay with family friends, where Charles learned to be content with little and disciplined in his studies.*
>
> *He grew up and went to the University of Illinois, where he met his wife, Frances. He wasn't able to complete college because of the threat of the draft at the outbreak of WWII. At the time, there was an experimental Air Force program in Tuskegee, Alabama, that was testing whether or not black men could learn the skills necessary to effectively fly in combat. Charles applied in hopes of escaping the army draft and was one of the few selected to enter. He married Frances two days before his departure to the Tuskegee training base. After training, his squadron was sent out to war despite acute resistance from all but one general*

who opposed blacks serving under them, and they were tasked with protecting bombers during raids over German territory. They succeeded, more than any other squadron, never losing a single bomber to German resistance.

This theme continues with Charles displaying grace to those who were ignorant towards him and his black comrades, continuing to serve with excellence the very men who insulted him. He went on to serve as an American pilot in the Korean War and the Vietnam War. He also displayed excellent leadership skills while serving during the Cold War in Italy and Minot, North Dakota, accepting all and seeking to understand everyone's side of the story. The resistance all blacks felt due to their skin color only made him better at empathizing with those who were under his command as he continually got promoted. After retirement, Charles refused to sit still, going on to work as a manager of a business, an airport, and the Tuskegee Airmen Institute, to name a few.

One significant part of Charles' story is when his wife, Frances, contracted a blood disease and her health slowly decayed over the ensuing year. Charlene recounts how Charles stayed by her mom's side and ministered to her every need without complaint, all the way until her death. It took a while for him to recover, but eventually he was back on his feet and answering the call to a multitude of speaking engagements. Another significant moment in the book was when Charles was honored near the end of his life for completing a total of 409 flying missions over the course of three wars, more than any pilot in the US Air Force at that time. This book opened my eyes to the history of American racial prejudice like I had never seen before, and made me grateful for the progress in civil rights that my generation has been blessed with. I also feel inspired by the diligence and loyalty Charles showed to his country and his family, and it inspires me to do the same."

For this student, the most important themes from their book were non-technical; however, they gained a new perspective on the intersection of race and military aviation from the 1930s to the 1980s.

The final component of the Book Project was the class presentation. Each student was exposed to one historical narrative through their book, and then they shared that narrative with the class. This allowed other students to benefit from fifteen other presentations about aerospace technology, while also providing students the opportunity to practice presentation skills with their peers. Students were given the following requirements for their 4–7-minute presentation:

- What book did you read (Title, Author)? What was the book about?
- What were the links between aerospace engineering and society in your book?
    - Did the characters confront ethical implications?

    - How did aerospace technology impact society?
    - How did society impact aerospace technology?
- How does the material we have covered in class relate to the book?
    - For example: if you are reading a book about the Battle of Britain, you can discuss how range or endurance of the Supermarine Spitfire was discussed in your book. Then, you can compare what was discussed in your book to a calculation you perform.
    - You need to perform a calculation (based on what we have covered in class) to connect to the material in your book, and you need to show your calculation to the class in the presentation.
- What was your favorite part of the book? Would you recommend your book?

The instructor allotted two 80-minute class periods for the 16 presentations. The students were attentive to their classmates, and students were encouraged to ask clarifying questions at the end of each presentation. Students heard presentations on different eras of aviation and astronautics, from the Wright Brothers to rocket planes and the Apollo space program, and they consistently did an excellent job describing how the story of their book was part of a larger cultural narrative.

Each presentation required a mathematical calculation, relating the content covered during class to the content of their book. The students presented a wide variety of calculations, including aircraft range/endurance, gliding distance, estimating lift-to-drag ratios, estimating stall speeds, and calculating orbital velocities/eccentricities. Figure 1 shows a sample calculation from one of the presentations. The student's book was about the lunar orbit rendezvous (LEO), so the student calculated the velocity required to gain a circular orbit around the moon. The student commented that their calculated value was slightly higher than the value stated in their book; this led to a class discussion about why that would be the case. (For the calculation, the student did not account for the altitude of the orbit and used the radius of the moon as orbital radius.)

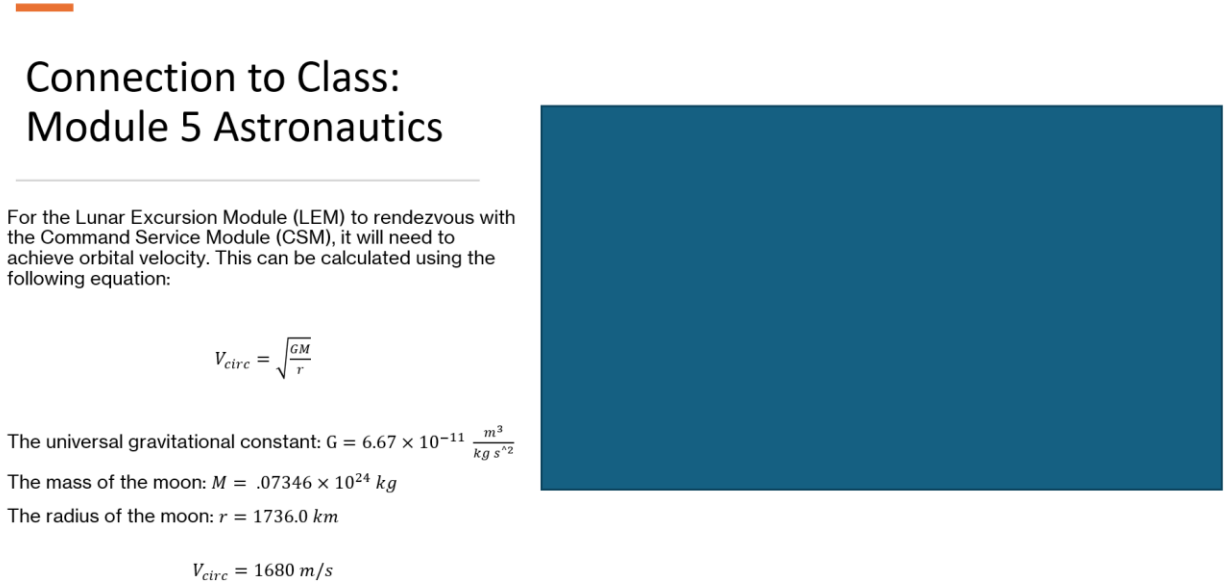

Figure 1: Example calculation from a student presentation (picture boxed out for copyright purposes)

Results

The learning objectives of the project were assessed directly (through matching pre- and post-project questionnaires) and indirectly (through conversations with students). The pre-questionnaire (shown in Appendix B) was administered during class within one week of the students selecting their book. The post-questionnaire (also shown in Appendix B) was administered during class on the last day of the semester, one week after the students completed their presentations. Students generated a repeatable four-character identifier based on their mother's first name, middle name, and birthdate; this allowed for matching responses between the two questionnaires. Sixteen students completed the project, but the results below show fourteen (N = 14) matched responses due to student absences during the questionnaire dates. The questionnaires were anonymous, but some students commented that the small class size and the collection of demographic information (major, graduation date) could lead to deanonymization. The instructor assured the students that the responses would in no way affect their grade on the project or in the course.

The questionnaire was a combination of five-point Likert scale and free response questions. The Wilcoxon Signed Ranked Test [44] was used to reject the null hypothesis (no statistically significant change in responses between the pre- and post-questionnaires.) Due to the small sample size, the level of significance for rejecting the null hypothesis (α) was set at 0.1. It should be noted that there is debate in the literature about what type of test should be used on discrete datasets (like Likert scale results), particularly for small sample sizes [45], [46], and some of the underlying assumptions for the Wilcoxon test are not valid for this dataset. These limitations

(along with the small sample size) limit the power of the results; nevertheless, the authors decided that using a significance test would provide additional insight.

Table 3 shows the responses to the first eight Likert-scaled questions, from strongly disagree (1) to strongly agree (5). These questions were designed to show how students consider the interactions between aerospace engineering, history, and society; and relating these concepts to practicing engineering. Questions A2 and A8 asked about aerospace engineering shaping culture and culture shaping aerospace engineering; for both questions, almost every student agreed with the statement on the post-questionnaire, and the difference between the pre- and post-questionnaires was statistically significant. Question A1 also asked about engineering in a cultural context; ten out of fourteen students agreed with the statement on the post-questionnaire.

Questions A4 and A7 asked students about their responsibilities as engineers. Engineering is not value-neutral, and the actions of engineers have implications on the world around us [47]. Most of the students (11/14 on A4, 13/14 on A7) agreed with these statements, but the project did not strongly impact how students answered these questions. On Question A5, students were given the prompt: "I need to understand my field's history to be a successful engineer." Eight of fourteen students increased their rating on this prompt from the pre-questionnaire to the post-questionnaire. Similarly, seven out of fourteen students increased their rating of prompt A6 ("Being a well-rounded reader will help me professionally"). The survey results show that the project helped students see a professional benefit from reading and studying the history of their field.

Table 4 shows the responses to the second set of Likert questions, from strongly disagree (1) to strongly agree (5). One of the goals of this project was to foster a desire for lifelong learning through reading. To measure this, the survey included questions about interest in reading in different subject areas. An increase in interest in reading between the pre- and post-project questionnaire would indicate an increased desire for future learning in that subject area [48]. Students showed a statistically significant change in enjoyment for reading about history and science/engineering; this was an encouraging result, given that the average student read 1.5 non-fiction books and 2.3 fiction books over the previous year (data from the pre-questionnaire). Nine of the fourteen respondents on the post-questionnaire showed motivation to continue reading about their chosen topic (or a topic related to one of their classmates' presentations) within the next six months.

Table 3: Comparison of Pre- and Post-Project Questionnaire Results (Matched Responses, N = 14); Question Set A

Question	Prompt	Pre-Project Median	Post-Project Median	Pre-Project: Agree or Strongly Agree	Post-Project: Agree or Strongly Agree	Shift in Mean	# Of Respondents with Score Increase	# of Respondents with Score Decrease	Reject Null Hypothesis? ($\alpha = 0.1$)
A1	Engineering happens within a specific cultural context.	4	5	9	10	+0.29	5	2	No
A2	The designs created by aerospace engineers have shaped culture and society.	5	5	13	14	+0.29	4	0	Yes
A3	Studying the history of aeronautics and astronautics will increase my understanding of engineering concepts.	4	5	12	11	+0.21	7	3	No
A4	I have a responsibility as an engineer to understand the history of my profession.	4	4	10	11	+0.21	5	2	No
A5	I need to understand my field's history to be a successful engineer.	4	4	8	10	+0.5	8	2	Yes
A6	Being a well-rounded reader will help me professionally.	4	5	12	13	+0.5	7	1	Yes
A7	I have a responsibility as an engineer to help those around me flourish.	4	4	12	13	0	4	5	No
A8	The designs created by aerospace engineering have been shaped by culture and society.	4	5	10	13	+0.86	9	0	Yes

Table 4: Comparison of Pre- and Post-Project Questionnaire Results (Matched Responses, N = 14); Question Set B

Question	Prompt	Pre-Project Median	Post-Project Median	Pre-Project: Agree or Strongly Agree	Post-Project: Agree or Strongly Agree	Shift in Average Response	# Of Respondents with Score Increase	# of Respondents with Score Decrease	Reject Null Hypothesis? ($\alpha = 0.1$)
B1	I enjoy reading literature.	3	4	7	10	+0.50	7	2	No
B2	I enjoy reading about science/engineering.	3.5	4	5	11	+0.71	8	1	Yes
B3	I enjoy reading about history.	3	4	9	10	+0.71	9	2	Yes

Table 5 shows the responses to the third set of Likert questions, from strongly disagree (1) to strongly agree (5). (On Question D, the Likert scale was: Horrible Idea, Bad Idea, Neutral, Good Idea, Great Idea.) These questions were designed to reveal student perceptions of the project in relation to this course and their career. The results from these questions were very encouraging:

- Thirteen out of fourteen students thought they would be a better engineer for reading their book.
- Students were more likely to say they "enjoyed reading" their book, compared to being "excited to read" their book before the project.
- Eleven out of fourteen students on the post-questionnaire "agreed" or "strongly agreed" that reading their book motivated them to learn more about aerospace engineering.
- All fourteen students stated that reading their book helped them relate to course content.
- All fourteen students stated that reading the book as part of the course was a "good idea" or "great idea."

Table 5: Comparison of Pre- and Post-Project Questionnaire Results (Matched Responses, N = 14); Question Sets C and D

Question	Prompt	Pre-Project Median	Post-Project Median	Pre-Project: Agree or Strongly Agree	Post-Project: Agree or Strongly Agree	Shift in Average Response	# Of Respondents with Score Increase	# of Respondents with Score Decrease	Reject Null Hypothesis? ($\alpha = 0.1$)
C1	I believe I will be a better engineer for reading my selected book.	4	4	9	13	+0.57	8	0	Yes
C2	I (am excited to read/enjoyed reading) my book for the ENGR 4335 Book Project.	4	5	10	12	+0.57	9	2	Yes
C3	(Reading my book will motivate me/My book motivated me) to learn more about aerospace engineering.	4	5	8	11	+0.50	7	1	Yes
C4	Reading my book (will help me/helped me) relate to the content in this course.	4	5	8	14	+1.00	9	0	Yes
D	Which best describes your opinion about being assigned to read a non-fiction book as part of this course?	4	4	10	14	+0.64	8	0	Yes

The final question on the post-questionnaire asked for comments about the book project. Apart from one neutral response ("Pretty good, didn't take too much time away from regular class time") and one constructive comment ("I think some more accountability assignments might help, just like a questionnaire on how far we have come in reading throughout the semester"), responses were positive, with no negative feedback about the project:

- "I enjoyed the project and learning about propulsion and orbital mechanics through the book. As well as the engineering design."
- "Made the course interesting beyond the math & gave the course depth that I believe benefitted my understanding of the world."
- "I'm very interested in aerospace due to my book and this class."
- "One of my favorite parts of the class."

- “I actually really enjoyed it.”
- “I really enjoyed the project; please continue to do it.”

Informal interactions with students provided additional feedback about the project. Throughout the project, the instructor had many productive conversations with students about their books. At least five of the sixteen students shared through conversation that they enjoyed reading their book. Several students also commented on the connectivity of the different presentations in class. For example, students saw how the Cold War was a common thread in both the space race (the Apollo program, discussed in two presentations) and military aviation (discussed in four presentations). This idea was also noted in the responses in the post-questionnaire; in response to the question “What was an interesting fact (or takeaway) from watching your classmate's presentations?” students submitted the following responses:

- “Most of the stories involved common “parent” companies (Bell, Lockheed, etc.)”
- “The secrecy of engineering because of politics/ways was surprising and prevalent in many presentations.”
- “I thought the presentations about the space race were really interesting since there were several that related to each other.”
- “Pilots are … as crucial to the design (of a plane) as engineers.”

The last comment stems from the fact that several of the presentations were biographies of military and/or test pilots. These memoirs reminded students that engineering designs (in this example, planes) are designed with humans in mind (in this case, pilots) [49].

Summary, Conclusions, and Future Work

This work describes the implementation of non-fiction reading into an introductory aerospace engineering course. Students selected a narrative non-fiction book, wrote a short report, and presented the content of their book to the class. The book project accomplished all three goals that were set at the project onset:

- Students successfully applied course material (such as aircraft range/endurance and orbital velocities) to a historical aerospace application and shared this information with the class.
- The class unanimously thought they would be better engineers for reading their selected books, and a majority of the class expressed interest in future reading about aerospace history. However, it is unclear to what extent this project motivated students to continue reading as a form of lifelong learning.
- Students saw a direct link between aerospace history and the historical/societal context of the past 120 years, from the Wright Brothers to the Cold War.

The project could be modified for a larger class by having groups of students read the same book; each group would discuss their book and present key points to the class. Another

modification for larger classes (or classes delivered online) would be requiring the students to record presentations and upload them to the LMS to be viewed and evaluated by the other students and the instructor. This would also allow for greater discussion about each presentation since the time allotted for discussion would not be limited by the length of the class period.

The results obtained from the pre- and post-questionnaires are inherently limited by the small class size, and class size/frequency of course offering (once every three semesters) made establishing a control group for this study a challenge. The authors would enjoy working with other instructors who implement similar projects in their courses to further understand the impacts of non-fiction narrative reading in aerospace classes. It would also be helpful to check in with students 1-2 years after the completion of the course, to see if the project influenced their reading patterns and desire to learn about aerospace engineering.

The authors plan on adjusting and improving the project in future semesters. The intent of the short book report was for students to think critically about their book and distill the main themes. Despite a class conversation about the purpose of the assignments, the authors suspect that at least two students submitted reports authored solely by an LLM. It was not clear if these students finished their book or read just enough of the book to complete the project deliverables. The book report may be changed to a short professor/student interview; an in-person conversation would help the instructor distinguish if the student read their book. Another way to increase accountability would be to incorporate peer evaluations during the class presentations. Students would be accountable to each other to accurately present their material, and the non-presenting students would be more engaged during their classmates' presentations [50], [51].

Based on feedback from the students and the instructor, several changes will be made to the book list before it is used again in future classes. First, a student mentioned the book they read was not very narrative in style – they felt it read more like a series of arguments than a cohesive narrative. That book will be removed from the list of books for future courses. Second, several of the books were less technical in nature than the other books, which meant the students that read them were not able to contextualize what they were learning in the course as well as students that read more technical books. It also presented a challenge to the students in finding book content that could be used for the mathematical calculation required in their presentation. Based on the course instructor's recommendation, those books will be removed from the list. Finally, instructions for using a screen reader to read ebooks aloud to the reader will be added to the LibGuide. Six students expressed a preference for audiobooks in the post-questionnaire, so providing directions for listening to ebooks will make that option available to future students who have a similar preference.

Shortly after the book selections were finalized, the University of Mary Hardin-Baylor was designated a Hispanic Serving Institution. The list of book selections did not include any books that predominantly feature Hispanic individuals and their contributions to the field, so that will be rectified before the book list is used again. The book list was also missing books on

international figures in aerospace engineering, as well as neurodivergent and physically disabled contributors to the field. As mentioned previously, the intent is for books to be “mirrors, windows, and sliding glass doors” to readers [41], so future book selections for the list will be made with the intention of increasing the diversity of the books on the list.

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Appendix A – Book List

	Print/Ebook	Diverse Perspective?	Selected By Student?
D. Alef, Burt Rutan: Aeronautical and space legend. Jersey City, NJ: Meta4 Press, 2016.	Print		
W. J. Boyne, Beyond the Horizons: The Lockheed story. New York: Thomas Dunne Books, 1998.	Print		Yes
B. Gunston, Grumman: Sixty years of excellence. New York: Orion Books, 1988.	Print		
S. Hamilton, Air Wars: The global combat between Airbus and Boeing: Untold stories reveal the man and the strategies that changed aviation. 12s Publications, 2021.	Print		
P. Handleman, Soaring to Glory: A Tuskegee airman's firsthand account of World War II. Washington, DC: Regnery History, 2019.	Print	Yes	
R. Hough and D. Richards, The Battle of Britain: The greatest air battle of World War II. New York: Norton, 1989.	Print		
C. L. Johnson and M. Smith, Kelly: More than my share of it all. Washington, D.C.: Smithsonian Institution Press, 1989.	Print		
T. J. Kelly, Moon Lander: How we developed the Apollo lunar module. Washington, D.C.: Smithsonian Institution Press, 2001.	Print		Yes
G. Kranz, Failure is Not an Option: Mission control from Mercury to Apollo 13 and beyond. New York: Simon & Schuster, 2000.	Print		
D. McCullough, The Wright Brothers. New York: Simon & Schuster, 2015.	Print		Yes
K. O'Brien, Fly Girls: How five daring women defied all odds and made aviation history. Boston, MA: Houghton Mifflin Harcourt, 2018.	Print	Yes	
K. Oliver, To Touch the Face of God: The sacred, the profane and the American space program, 1957-1975. Baltimore, MD: Johns Hopkins University Press, 2013.	Print		Yes
B. R. Rich and L. Janos, Skunk Works: A personal memoir of my years at Lockheed. New York, N.Y.: Back Bay Books/Little, Brown and Company, 1994.	Print		Yes
P. Robison, Flying Blind: The 737 MAX tragedy and the fall of Boeing. New York: Doubleday, 2021.	Print		
A. Rose, Empires of the Sky: Zeppelins, airplanes, and two men's epic duel to rule the world. New York: Random House, 2020.	Print		Yes
D. J. Shayler, The Hubble Space Telescope: From concept to success. New York: Springer, 2016.	Print		

	Print/Ebook	Diverse Perspective?	Selected By Student?
M. L. Shetterly, Hidden Figures. New York, NY: William Morrow, 2016.	Print	Yes	Yes
D. V. Smith, Ed., One Hundred Years of U.S Navy Air Power. Annapolis, MD.: Naval Institute Press, 2010.	Print		
T. Wolfe, The Right Stuff. New York: Black Dog & Leventhal, 2004.	Print		
B. Yenne, B-52 Stratofortress: The complete history of the world's longest serving and best known bomber. [Place of publication not identified]: Zenith Press, 2018.	Print		Yes
G. Abney, Wings Over Illinois. Carbondale, IL: Southern Illinois University Press, 2007. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook	Yes	
M. W. Bowman, The Men Who Flew the Hawker Hunter. [Place of publication not identified]: Pen & Sword Aviation, 2019. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		Yes
H. H. Brown and M. S. Bordner, Keep Your Airspeed Up: The story of a Tuskegee airman. Tuscaloosa, AL: University Alabama Press, 2017. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook	Yes	Yes
J. H. Casper, The Sky Above: An astronaut’s memoir of adventure, persistence, and faith. West Lafayette, IN: Purdue University Press, 2022. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		
W. F. Causey, John Houbolt: The unsung hero of the Apollo moon landings. West Lafayette, IN: Purdue University Press. 2020. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		Yes
M. Croft and J. Youskauskas, Come Fly with Us: NASA's payload specialist program. Lincoln, NE: University of Nebraska Press, 2019. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook	Yes	
B. Gilliland and K. Dunnavant, Speed: The life of a test pilot and birth of an American icon. Lincoln, NE: Potomac Books, 2021. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		Yes
T. Kessner, The Flight of the Century: Charles Lindbergh and the rise of American aviation. New York: Oxford University Press, 2010. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		
C. F. G. Kuyk, Jr. and C. F. G. Kuyk III, West Point Graduates and the United States Air Force: Shaping American aerospace power.	Ebook		

	Print/Ebook	Diverse Perspective?	Selected By Student?
Jefferson, NC: McFarland, 2020. [Ebook]. Available: eBook Academic Collection (EBSCOhost).			
R. Lloyd, Fast Jets to Spitfires: A Cold War fighter pilot's story. Yorkshire: Air World, 2020. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		
C. E. McGee, Tuskegee Airman: The biography of Charles E. McGee, 5th ed. Boston, MA: Branden Books, 2012. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook	Yes	Yes
G. McIlmoyle and L. R. Bromley, Remembering the Dragon Lady: Memoirs of the men who experienced the legend of the U-2 spy plane. West Midlands: Helion and Company, 2011. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		
K. Oliver, To Touch the Face of God: The sacred, the profane, and the American space program, 1957-1975. Baltimore, MD: Johns Hopkins University Press, 2013. [Ebook]. Available: ProQuest Academic Complete.	Ebook		Yes
R. Paul and S. Moss, We Could Not Fail: The first African Americans in the space program. Austin, TX: University of Texas Press, 2015. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook	Yes	Yes
C. Petty, Beyond Blue Skies: The rocket plane programs that led to the space age. Lincoln, NE: University of Nebraska Press, 2020. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		Yes
S. B. Rickman, WASP of the Ferry Command: Women pilots, uncommon deeds. Denton, TX: University of North Texas Press, 2016. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook	Yes	
F. Trapnell and D. T. Tibbitts, Harnessing the Sky: Frederick 'Trap' Trapnell, the U.S. Navy's aviation pioneer, 1923–1952. Annapolis, MD: Naval Institute Press, 2015. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		
S. Tsiao, Piercing the Horizon: The story of visionary NASA chief Tom Paine. West Lafayette, IN: Purdue University Press, 2017. [Ebook]. Available: eBook Academic Collection (EBSCOhost).	Ebook		

Appendix B – Pre- and Post-Project Questionnaires

Students were given the following questionnaire before and after the project. Individual student responses were matched through unique identifiers (generated using personal data about the students' mothers). Text in **bold** was only included on the pre-questionnaire, and text in *italics* was only included on the post-questionnaire.

Please select your level agreement with each of the following statements by placing an "x" in the appropriate column for each row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Engineering happens within a specific cultural and historical context.					
The designs created by aerospace engineers have shaped culture and society.					
Studying the history of aeronautics and astronautics increased my understanding of engineering concepts.					
I have a responsibility as an engineer to understand the history of my profession.					
I need to understand my field's history to be a successful engineer.					
Being a well-rounded reader will help me professionally.					
I have a responsibility as an engineer to help those around me flourish.					
The designs created by aerospace engineering have been shaped by culture and society.					

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I enjoy reading literature.					
I enjoy reading about science/engineering.					
I enjoy reading about history.					

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I believe I will be a better engineer for reading my selected book.					
I (**am excited to read**/*enjoyed reading*) my book for the ENGR 4335 Book Project.					
(**Reading my book will motivate me**/*My book motivated me*) to learn more about aerospace engineering.					
Reading my book (**will help**/*helped*) me relate to the content in this course.					

Please answer the following questions:

How many non-fiction books have you read in the last year?	
How many fiction books have you read in the last year?	
What types of books (if any) do you read? (Do not include class materials, such as textbooks.)	
How many times have you visited the [UNIVERSITY] library in the last year?	
How many times have you visited <u>any</u> library in the last year?	

Did you utilize the [UNIVERSITY] library to access your book?	
What format was your book (print, ebook, audio)? Would you have preferred it to be in a different format, and if so, what?	
Did this project motivate you to read a non-fiction book (that you otherwise would not have read) within the next six months? If yes, what book/subject?	
What was an interesting fact (or takeaway) from watching your classmates' presentations?	

	Horrible Idea	Bad Idea	Neutral	Good Idea	Great Idea
(Now that you have read your book:) which best describes your opinion about being assigned to read a non-fiction book as part of this course?					

Do you have any comments about the book project?	