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Evaluating the Incorporation of Artificial Intelligence into Naval Flight Education

June 2024

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ABSTRACT

Artificial intelligence (AI) has taken the world by storm. As the technology advances, the United States Military and its branches are eager to find ways in which the incorporation of this evolving technology can increase mission effectiveness. In the U.S. Navy, the aviation community is curious about the ways in which AI would impact naval flight education. This study aims to identify the positive and negative implications of incorporating AI into naval flight education, with a focus on the first phase of flight training, Naval Introductory Flight Evaluation (NIFE). This study uses library research as the primary method of research. The result analysis of this research identifies limitations of the current NIFE curriculum, explains the potential benefits of AI-based tools, discusses challenges that need to be addressed before adopting this technology, and makes suggestions for areas of future research on this topic. Using published research on the effectiveness of AI tools in education and aviation, this study concludes that tools such as Intelligent Tutor Systems (ITS) and AI-based virtual instructors have significant potential to make knowledge acquisition and skill development more efficient and available for Student Naval Aviators (SNAs). This study also concludes that there is significant need for future research in development and validation before these tools can be most effectively implemented in the Naval Aviation Training Curriculum.

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
API	Aviation Pre-Flight
BN	Bayesian Networks
CFI	Certified Flight Instructor
CIP	Certified Instructor Pilot
CNATRA	Chief of Naval Air Training
CPR	Cardiopulmonary Resuscitation
DoD	Department of Defense
DOR	Drop on Request
IFS	Introductory Flight Screening
ITD	Integrated Training Device
ITS	Intelligent Tutor System
NIFE	Naval Introductory Flight Evaluation
NSS	Naval Standard Score
SNA	Student Naval Aviator
TTT	Time to Train
VIPER	Virtual Instructor Pilot Exercise Referee
VR	Virtual Reality
XR	Extended Reality

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I. INTRODUCTION

Due to increasing operational demands and a limited pool of qualified instructors, the U.S. Navy's flight training pipeline faces backlogs in producing mission-ready aviators and inefficiencies in traditional training methods (Brophy & Chomic, 2024). As Artificial Intelligence (AI) technologies advance, this presents an opportunity to modernize flight education (Forcier et al., 2016; Hafer et al., 2019). By adopting AI-based learning approaches, Naval aviation training could improve learning efficiencies, expedite training processes, reduce instructor workloads, and allocate resources appropriately.

This study reviews how AI may enhance the U.S. Navy's flight training pipeline, particularly in the Naval Introductory Flight Evaluation (NIFE) training phase. It identifies how AI technologies, such as AI instructors like TakeFlight AIVIator, may offer enhanced efficiency, effectiveness, and scalability (TakeFlight Interactive, 2023).

This research discusses several areas where AI can provide substantial impacts: advancements in academic instruction through personalized learning (Forcier et al., 2016), advanced simulation technology that can better replicate real-world flying scenarios (Lintern et al., 1990; Zhang, 2021), adaptive learning systems that adjust training methods based on the trainee's performance and progress (Forcier et al., 2016), and automated feedback systems capable of providing immediate and targeted feedback to pilots allowing them to improve their proficiency and skill in real-time (Zhang, 2021). Additionally, this research examines how AI can support overall training management, including scheduling, resource allocation, and performance accountability efficiencies to create an effective training environment for Navy pilots. The study aims to demonstrate how AI can create opportunities for a comprehensive transformation of flight training in the Navy.

This study examines the potential integration of AI technologies into the context of NIFE and flight training. The primary research question is:

1. How can AI technologies assist learning in Naval flight training to maximize the effectiveness and efficiency of flight training while reducing the current backlog?

This research also explores several supporting questions to evaluate the impacts on cost, time, and performance. The supporting questions are:

1. In what ways is AI leveraged in education to facilitate learning?
2. Can AI tools be used to enhance simulator training for pilots?
3. Would implementing artificial intelligence into Naval Introductory Flight Evaluation be cos- effective?
4. What are the potential limitations and risks of incorporating AI into flight school?
5. How can AI help mitigate delays in NIFE?

These questions are studied through literature research. A cost-benefit analysis framework is used to assess the use of AI versus traditional flight training methods. This study comprises a comprehensive literature review that examines the application of AI in military and civilian flight training environments and drawing comparisons with existing initiatives. This study examines how AI-supported formats can improve efficiency within the Naval aviation training pipeline, focusing on gains in efficiency, training outcomes, and costs. This research is limited to training environments and does not examine long-term operational performance. Key limitations of this research include budget restraints, time constraints, and limited access to proprietary AI systems (Hicks, 2021).

This study is organized into six additional chapters. The background chapter of this study details an overview of flight school, with a focus on Naval Introductory Flight Evaluation. The background also discusses AI and TakeFlight Interactive, an AI tool being utilized by the Navy. The literature review chapter comprises three sections, each covering reviewed sources: studies on NIFE, AI in aviation, and AI in education. The methods chapter describes the research decisions of this study and the guiding reasoning used to answer the study's primary and supporting questions. A cost-benefit analysis is conducted to evaluate how AI can help reduce costs in flight school. The findings and discussion chapter contains the relevant findings from the research and discusses the implications of these findings. Lastly, the conclusion chapter summarizes the study, answers the primary and supporting questions of this study, and suggests areas for further research.

II. BACKGROUND

This chapter provides an overview of the Naval aviation training pipeline, the first step in the training pipeline, and the role of Artificial Intelligence (AI) in both aviation and education.

A. OVERVIEW OF FLIGHT SCHOOL

The United States (U.S.) Navy currently produces approximately 1,100 new pilots every year (Prasad-Rao et al., 2023). The pipeline to becoming a Naval aviator is neither quick nor easy. Student Naval Aviators (SNAs) start their pipeline with a program known as Naval Introductory Flight Evaluation (NIFE). NIFE introduces SNAs to the world of flight, where they begin their journey to earn their wings of gold. Following the completion of NIFE, students proceed to the next stage of flight school, known as Primary. All SNAs that move to Primary begin flying an aircraft known as the T-6B Texan II (Chief of Naval Air Training, 2025). Upon completion of the Primary phase of flight school, SNAs are then assigned to fixed-wing aircraft or rotary-wing aircraft. To differentiate the two, fixed-wing aircraft are typically jets, and rotary-wing aircraft are typically helicopters. The next stage of flight school for SNAs who selected fixed wing is known as Intermediate. Upon completing Intermediate, SNAs proceed to the final phase of flight school, Advanced. SNAs that select rotary-wing move directly from Primary to Advanced, as no Intermediate phase exists for rotary-wing pilots. Figure 1 gives an overview of the pipeline for SNAs described above. After SNAs complete the Advanced phase, they earn their "wings of gold," solidifying their titles as naval aviators.

Figure 1. Flight School Pipeline. Source: Chief of Naval Air Training (n.d.).

B. NAVAL INTRODUCTORY FLIGHT EVALUATION

NIFE is an introductory course for student Naval aviators. The program was first introduced in August of 2020 in order to streamline the process of producing naval aviators (Lambert, 2022). NIFE serves as a consolidation of screening and indoctrination courses for student naval aviators. This course is the first step in a student's journey to becoming a naval aviator. NIFE is a program designed to teach the fundamentals of aviation while simultaneously serving as a screening tool by putting the students through stressful evolutions (United States Navy, 2022). One pilot has been quoted as saying that "NIFE is the bridge from commissioning to Primary flight training and for many students, it's their first time experiencing what it means to be a military officer" (Ballew, 2022).

NIFE is a two-phase course consisting of four distinct parts, which typically take students nine to thirteen weeks to complete (Ballew, 2022). The first part of NIFE includes administrative events and water survival training [See Appendix A]. Administrative events involve gear fitting, issuance, medical screenings, and a Physical Readiness Test (NASCINST, 2023). Following these events is the Intermediate Water Survival Course (IWSC), which ensures that students are comfortable in the water while wearing necessary aviation gear (Ballew, 2022). During IWSC, students learn crucial survival tactics such as cardiopulmonary resuscitation (CPR). Once students complete all administrative and water survival events, they advance to NIFE 1. NIFE 1 is the ground portion, or academic phase of NIFE (Ballew, 2022). This phase tests the students' retention skills and their ability to manage time efficiently (Ballew, 2022). Lasting only three weeks, this phase requires students to pass multiple exams that assess their knowledge in five subjects: aerodynamics, engines, flight regulations, navigation, and weather (See Appendix A-1). After passing exams in each of the five areas, students proceed to the flying portion of NIFE. This marks the first time students will sit in the cockpit of a real plane. Known as NIFE 2, this phase requires students to quickly memorize flight maneuvers and emergency procedures while in the plane. To pass NIFE 2, students must perform several standardized maneuvers while being observed by an instructor pilot (Ballew, 2022). Students need to recall emergency procedures during pre-flight briefs to demonstrate to the instructor pilot that they have studied and memorized the required knowledge (Ballew, 2022). After completing and passing the seven flights in NIFE 2, students move on to the final part of NIFE, which is the aviation physiology phase (NASCINST, 2023). During this phase, students participate in emergency training evolutions, including emergency first aid training, the hypoxia chamber, and the "helo-dunker" (Ballew, 2022). Upon completing these evolutions, students earn the right to wear their flight suits and advance to the next phase of flight training known as Primary.

C. ARTIFICIAL INTELLIGENCE

Naval flight school is undergoing a phase of digital modernization as the DoD aims to stay ahead of its adversaries in training and preparedness. In recent years, flight school has introduced new virtual reality simulator training to create a more efficient pathway in the training pipeline (Blow, 2023). Originally, a stack of books was placed in front of students, a few computer-based training sessions and lectures were provided, and then the flight training commenced (Freedberg, 2020). In an initiative known as Project Avenger, students receive a personal learning device that contains all learning materials in digital form readily accessible at their fingertips (Astwood et al., 2022). The initiative also features newer, more affordable simulators equipped with virtual-reality goggles, allowing students to practice at their convenience, rather than waiting for traditional simulators. This project enables smaller class sizes, giving instructors more time to understand each student and tailor individualized instruction (Freedberg, 2020). Since this project began in 2020, Rear Admiral Greg Harris noted that with the data derived from this initiative and as AI advances, this form of learning can furnish instructors with much more detailed insights into each student's performance (Freedberg, 2020).

AI can be utilized in educational settings in various ways. The tools that can be integrated into Naval flight training include intelligent tutoring systems, adaptive learning platforms, and enhanced simulations. One source noted that intelligent tutoring systems are a subset of artificial intelligence that includes computer programs which "analyze a student's current knowledge, learning pace, and their preferred learning style," emphasizing the scale at which artificial intelligence can be used uniquely for each (Park University, 2025). Intelligent tutoring systems are applicable to flight training as they monitor the student's actions and can respond with coaching in real time. The intelligent tutoring system has the ability to correct mistakes as the student is making them (Butz et al. 2024). This type of learning allows students to continue moving through the pipeline more efficiently. The Naval Air Warfare Center has explicitly stated that they are working to implement intelligent tutoring and AI across training areas (Naval Air Warfare Center Training Systems Division, 2021). As AI continues to improve, it is essential for the United States military to utilize it in productive ways, such as training warfighters.

Adaptive learning platforms are another resource of AI that works to deliver a unique teaching style to each student. Like intelligent tutoring systems, adaptive learning platforms utilize data unique to each student to offer a personalized learning experience that is suitable for the individual (Montclair State University, n.d.). The Navy has already started using digital courseware and has embraced a more electronic approach to learning in portions of flight school such as NIFE. Adaptive learning is an alternative to the legacy curriculum where each student is taught the same way.

D. TAKEFLIGHT INTERACTIVE

In recent years, the Chief of Naval Air Training Command (CNATRA) has shown interest in a new artificial intelligence tool, known as TakeFlight Interactive (TakeFlight, 2023). This software, developed by a company named TakeFlight, serves as a learning tool for pilots in training. The program is designed to be compatible with most simulators currently available and in use (TakeFlight Interactive, 2025). It aims to help pilots maximize their training time. The software functions as a mastery tool for pilots, providing students immersed in the simulator with dynamic feedback and real-time instruction. This tool intends to accelerate the learning process, allowing pilots to progress through the pipeline more quickly. TakeFlight AIviator is the specific tool in which the Navy has invested for its Project Avenger (TakeFlight, 2025). The company has worked to develop a program that keeps students engaged throughout the learning process (TakeFlight, 2025).

E. SUMMARY

Flight school has a strict curriculum that thousands of students have passed over the years. There are specific requirements that SNAs must meet to progress through the stages of flight school and earn their wings. This chapter outlined the requirements of the first phase of flight school, known as NIFE. The Naval aviation training curriculum has evolved in recent years, with initiatives focusing on incorporating updated learning techniques and technology to enhance training effectiveness. AI has introduced a new way to train Naval aviators effectively, provided the tools are used correctly. The collaboration with TakeFlight Interactive and the U.S. Navy represents a development that could potentially revolutionize how naval aviators are trained. In the next chapter, a comprehensive review of the topics of NIFE, AI in aviation, and AI in education will be conducted, exploring the various methods artificial intelligence has already been integrated into flight school, along with tools that can expedite Naval flight training.

III. LITERATURE REVIEW

The purpose of this literature review is to provide further context for the questions posed by this study. This section will examine research on NIFE, as well as studies concerning AI in both military and civilian aviation, and the role of AI in education. These studies form the foundation of the research undertaken in this study.

A. STUDIES ON NIFE

Naval Introductory Flight Evaluation (NIFE) is the first stage of training to become a Naval aviator. Introduced in 2020 to replace Introductory Flight Screening (IFS) and Aviation Pre-flight Indoctrination (API), NIFE was designed as an update to these decades-old programs (Owens, 2020). The program was established to decrease Drop on Request (DOR) rates and enhance pilot performance by motivating student naval aviators (Owens, 2020). In one of the first empirical assessments of NIFE, Lambert (2022) studied the attrition rates and performance in Primary of over 4,500 student naval aviators, comparing those who completed NIFE to those who followed the legacy syllabus. In his study, Lambert found that attrition rates in Primary dropped by almost half when comparing students who completed IFS/API with those who completed NIFE. To further validate the success of the program, the study concluded that, on average, students in Primary who completed NIFE had a higher overall score than those who completed IFS. In 10 of 11 graded Primary events, NIFE students outperformed IFS students (Lambert, 2022). The results of this study support the structure and effectiveness of NIFE, expanding students' foundational aviation knowledge to better prepare them for the demands of Primary. Although NIFE has demonstrated success in reducing DOR rates and boosting performance, SNAs face new challenges in their pipeline. When initially adopted, SNAs could expect a wait time of around 13 weeks before starting each training phase (Freedman & Johnson, 2024). However, as of February 2024, this wait has increased to over 31 weeks (Freedman & Johnson, 2024). Flying is recognized as a perishable skill, meaning that proficiency declines as the wait time between training lengthens (Lambert, 2022). This is evident in Lambert's (2022) study, as SNAs were most likely to attrite in the early stages of Primary with fewer than 10 flight hours. To ensure that the value gained in NIFE translates to Primary, SNAs should progress through the training pipeline promptly, while also having access to resources that enable them to practice their skills during the wait.

The Center for Naval Analyses studies possible solutions for the wait time problem by evaluating changes to the NIFE syllabus (Freedman & Johnson, 2024). Proposed alterations include eliminating NIFE 2 flights altogether, replacing NIFE 2 flights with simulators, or reverting to the IFS and API syllabi (Freedman & Johnson, 2024). It was found that eliminating NIFE 2 flights would result in a net benefit of about 3.5 weeks gained back in time to train (TTT) and save $7.6 million annually (Freedman & Johnson, 2024). However, Freedman and Johnson (2024) recognized that sending SNAs to Primary with no flight experience could pose a safety risk and could eventually lead to a decline in both proficiency and completion of Primary. Ultimately, the study suggested replacing the four weeks of NIFE 2 with a two-week program, substituting the contracted flights with six simulator flights. This would require more military instructor pilots than the current syllabus uses since students would need to be trained and evaluated by military pilots (Freedman & Johnson, 2024). However, it would lead to a more fixed and predictable TTT by eliminating most weather and maintenance delays from the syllabus.

B. AI IN AVIATION

In 2020, the Naval Aviation Training Next initiative launched its first major syllabus revision (Astwood et al., 2022). Project Avenger aimed to streamline the Primary phase of flight instruction while enhancing student learning outcomes through modernized educational strategies (Astwood et al., 2022). The revisions signify a substantial evolution in the design and delivery of naval flight training, emphasizing flexibility, technological integration, and competency-based progression. Astwood et al. (2022) examined the impact of Project Avenger on SNA performance and TTT in Primary. The study found that the transition towards competency-based learning resulted in a more efficient system, with Avenger students completing the syllabus six weeks earlier than legacy students. Two key changes in this program are the incorporation of Integrated Training Devices (ITDs) and virtual reality (VR) headsets, along with redefining the role of instructors to learning facilitators instead of merely evaluators. These changes yielded promising results, aligning with educational trends that embrace feedback-driven instruction. While performance varied between legacy and Avenger students, the study noted that Avenger students faced more challenges due to the focus on mastering complex skills and the increased difficulty of the new syllabus (Astwood et al., 2022). Ultimately, the success of this approach depends on refining adaptive instruction and grading, increasing automation and efficiency, and enhancing simulation and immersive practice.

Arguing in favor of extended reality (XR) in aviation training, Flores et al. (2023) examined the use of XR technologies in aviation through an educational theoretical framework. The authors argued that the aviation industry underutilizes XR compared to other educationally focused industries. The authors studied the educational theoretical foundation, as well as XR technologies across various industries, in education, and in aviation (Flores et al., 2023). Through a comprehensive literature review, the authors concluded that XR can reduce stress and improve pilot confidence in the early stages of flight exposure by aiding in procedural and spatial training (Flores et al., 2023). They highlighted the importance of aligning XR use with educational theory, focusing on self-directed learning for adults, to maximize learning outcomes. Although the incorporation of these technologies is encouraged, it is noted that further research and experiments are necessary to implement them in the most effective and ethical way (Flores et al., 2023).

Butz et al. (2024) studied alternative AI decision support paradigms that could help pilots make more informed decisions. The traditional "recommendation centric" system provides end-to-end decision recommendations, encouraging pilots to reason backward after a decision recommendation (Butz et al. 2024). In contrast, a continuous support system aims to facilitate a forward-thinking decision-making process (Butz et al. 2024). This allows pilots to make their own decisions with the support of the system, which offers hypothetical options and scenarios, as well as facts about the situation, options, and associated risks and benefits (Butz et al. 2024). Butz et al. (2024) found that systems encouraging human-AI collaboration in forward reasoning helped pilots make more effective decisions in less time. This process-oriented decision support exemplifies an artificial intelligence capability that can aid student pilots as they begin training.

The Navy’s evaluation of an AI tool, the Virtual Instructor Pilot Exercise Referee (VIPER), indicates that AI-driven virtual instruction enhances both performance and student confidence in early flight training (Naval Air Warfare Center Training Systems Division [NAWCTSD], 2022). When comparing four groups of students, those who engaged in required VR practice with VIPER scored the highest overall in both Contact and Instrumental phases of Primary, received fewer unsatisfactory grades, and needed minimal additional training events (NAWCTSD, 2022). SNAs shared their opinions on VIPER through qualitative feedback, stating that they felt more prepared for flights after using the AI instructor (NAWCTSD, 2022). Additionally, most of the student pilots found the tool easy to use. However, students and instructor pilots alike expressed concerns about the technical limitations of the system (NAWCTSD, 2022). The results from this study provide strong evidence for the effectiveness of an adaptive AI instructor paired with VR practice.

C. AI IN EDUCATION

Though the use of AI in Naval flight training is relatively new, AI has proven to be an effective tool in broader education. Ma et al. (2017) found that intelligent tutoring systems (ITS) significantly outperform non-intelligent learning environments and perform similarly to human tutors. This research focused on Bayesian Networks (BNs) ability to track learner knowledge, allowing for adaptive instruction tailored to the individual learner (Ma et al., 2017). Echoing this sentiment, VanLehn (2011) found that an ITS performs at about the same effectiveness as individual tutoring. Similar to the BN research conducted by Ma et al., VanLehn (2011) identified that tutoring systems become more effective for an individual learner as the learner uses the system more frequently. Both studies provide compelling evidence that intelligent tutoring systems are powerful tools for individualized instruction.

D. SUMMARY

This literature review evaluates sources which study NIFE and discuss the use of AI in aviation and educational contexts. Studies on NIFE acknowledge the program’s success of increasing pilot performance in Primary and decreasing attrition, but highlights growing delays and logistical concerns which pose as major limitations in the training pipeline. AI technologies like XR, VR and ITS were found to offer promise in the aviation community to aid in pilot performance. Similarly, sources discussing the use of AI in education define ITS as a valuable tool for students, offering gains similar to individual human tutoring. In general, the literature supports the use of AI technologies to increase efficiency and effectiveness. This review serves as a foundation in evaluating the possibility of adopting AI as a supplement or replacement for the NIFE curriculum.

This literature review is limited in its scope. Existing sources focus on the incorporation of AI in later stages of flight school, but do not address the adoption of this technology into NIFE. Due to the current lack of use of AI in the aviation training community, there is insufficient analysis of the operational benefit of AI use in training. Lastly, this review does not address the risks related to over-reliance and technological limitations of AI. Further research on these topics is likely necessary before AI can be effectively adopted into the flight training curriculum

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IV. METHOD

Instead of gathering new empirical data, this study utilizes open source references in a qualitative research approach. This approach emphasizes analyzing previously published works to draw conclusions, identify trends, and construct a well-supported argument. Official Navy reports, scholarly articles on AI in education and aviation, and technical evaluations of training tools such as flight simulators and intelligent tutoring systems were collected and reviewed for this study. By utilizing existing sources, this research offers a broad, evidence-based foundation for assessing the impact of AI on Naval flight education.

The mission of NIFE is "to provide students with aviation fundamental knowledge, introduce students to military procedural-based aviation training and performance standards, conduct aeronautical adaptability screening, and decrease drop on request (DOR) and flight attrition and improve performance in primary flight training" (NASCINST, 2023). This study gathered information about various AI tools to evaluate their impact on NIFE's mission. If an AI tool was deemed to support or aid in enhancing NIFE's mission effectiveness, it was labeled as potentially beneficial. Since these tools have not yet been integrated into NIFE and lack statistical data to confirm their performance, it is important to note that their described value is based on their results in other contexts, thus rendering their contribution to NIFE's mission theoretical.

A cost-benefit analysis (CBA) was conducted to compare the current cost of NIFE with the potential savings from implementing AI in the curriculum and pipeline. By utilizing government contracts and resources that estimate the operational costs of conducting NIFE, the savings appeared substantial, especially in the long run. The advantages of a curriculum entirely based on artificial intelligence were not only financially favorable but also improved scheduling and timing for students and their progression through the pipeline.

The cost-benefit analysis was conducted by thoroughly researching different contracts awarded to private companies that would conduct NIFE for flight school. The analysis was broken down into three options including conducting NIFE in-house, contracting NIFE, and completing an entire curriculum through AI. These contracts were in the amounts of millions of dollars, this was the first step in assessing the expenses to conduct flight training. Following that, research was conducted in order to assess the contracts relating to AI tools that would benefit and potentially replace the traditional NIFE curriculum. Following that, there are other costs related to NIFE including the maintenance and upkeep of aircraft and simulators. Next, the cost-benefit analysis was stretched across a five-year time period, in order to account for the length of a typical NIFE contract and to account for the initial cost of implementing the infrastructure required to perform NIFE with AI. The costs were then multiplied by five in order to account for the five-year projected expenses. The final costs were then compared to one another to estimate savings amongst the options. The benefits of the options are qualitatively analyzed to highlight advantages, disadvantages and risks or each option.

V. COST BENEFIT ANALYSIS

Implementing any new technology into a training pipeline within the Department of Defense (DoD) is a lengthy process. The proposed implementation should prove cost-effective and deliver significant enhancements and benefits to the training. With any project, there are numerous costs associated with implementing new technologies and processes. As the data does not always explicitly state the specific costs, estimating some expenses becomes necessary. The U.S. Navy is committed to maximizing the potential of AI. Utilizing AI can help us stay ahead of our adversaries in training and preparedness. The DoD has already begun its search for companies to teach the nation's newest pilots the ways of the air (TakeFlight, 2023).

A. CONTRACTS

1. Naval Introductory Flight Evaluation

In August of 2023, the Naval Air Warfare Center issued a solicitation for companies to compete for providing the third phase of NIFE (NAWCTSD, 2024). The contract requires the chosen company to offer several capabilities to the flight school. These capabilities include providing certified flight instructors (CFIs) and a minimum of 24 identical Cessna-172 aircraft (HigherGov, 2024). The contractor is also responsible for the maintenance, equipment, and materials for their aircraft. This alleviates the pressure on the Navy to maintain its training aircraft for NIFE. The solicitation further requires the company to manage approximately 1660 students annually, which translates to more than 140 students each month (HigherGov, 2024). The contract is expected to last for one year, with five additional one-year option periods, totaling six years (HigherGov, 2024). It is estimated that the total value of the contract will range between five and ten million USD (HigherGov, 2024).

2. TakeFlight Interactive

In September 2023, the company TakeFlight was awarded a $5.5 million contract (TakeFlight Interactive, 2023). The contract extends the company's involvement in the initiative known as Project Avenger, which aims to teach student pilots a more flexible mindset in approaching flying. The initiative differs from the traditional syllabus in that flights normally canceled due to inclement weather would still be flown under this new approach (AN Aviation Services, 2023). Project Avenger seeks to improve efficiency in training new pilots through the continued use of virtual reality alongside the development of artificial intelligence (Astwood et al., 2022). TakeFlight Interactive and its AIVIator Virtual instruction platform are tools that help alleviate the pressures on instructor pilots while simultaneously increasing the production of new pilots (TakeFlight, 2025).

B. COST BREAKDOWN

1. Cost for AI Implementation

Over a five-year period, implementing artificial intelligence into NIFE would cost approximately $3.95 million per year, totaling almost $14.8 million over five years (Mullen, 2017; Varjo Technologies Oy, 2025; Toppo, 2024; Barbour, 2025). The cost of maintenance, upkeep, and updates for an AI simulator varies based on the model. The estimate in Table 1 refers to an F-15 simulator used by the U.S. Air Force. Additional contracting costs, such as compliance with national security standards, can vary depending on the sensitivity and type of contract. Although no specific cost for this compliance is provided, the estimation in Table 1 is based on similar contracts with simulators. TakeFlight's contract suggests delivering fifty simulators, which corresponds to the fifty VR headsets priced at $6,000 per unit, with replacements recommended every 2.5 years (Varjo Technologies Oy, 2025). The AI tutoring estimate is based on a Stanford study that estimated the cost of providing a basic AI tutor to students at $20 per student annually (Toppo, 2024).

Table 1. Estimated Cost of Implementing AI into NIFE

Item	Description	Cost over 5 Years	Annualized
TakeFlight AIviator	AI-enabled training platform including 50 systems	$5.5 million	$1.1 Million
AI Tutoring System	Tool designed to assist learning	$166,000	$33,200
VR Headsets	Headsets used to immerse students into the simulator	$360,000	$72,000
Maintenance and Support	Updates, license, etc.	$2.5 Million	$500,000
Cybersecurity Compliance	Necessary precautions taken by the DoD	$1.25 Million	$250,000
Staff	10 GS-13 Federal Employees	$5 Million	$1 Million
Total		$14.8 Million	$2.95 Million

Source (from top to bottom): TakeFlight Interactive (2023); Toppo (2024); Varjo Technologies Oy (2025); Mullen (2017); Barbour (2025); FederalPay.org (2024).

2. Outsourcing NIFE Cost

The U.S. Navy and Naval Air Training Command presently outsource to a private contractor to conduct certain training in NIFE. This contract is projected to cost the Navy $5 million annually, as indicated in Table 2 (NAWCTSD, 2024). It encompasses civilian instructors, aircraft, and maintenance services.

Table 2. Cost of Outsourcing NIFE

Item	Description	Cost over 5 Years	Annualized
NIFE Contract	Execute NIFE curriculum with the necessary equipment	$25 Million	$5 Million

Source: NAWCTSD (2024).

3. U.S. Navy Conducting NIFE Costs

For the Navy to conduct NIFE themselves, it would cost approximately $7.5 million each year (ZipRecruiter, 2025; Epic Flight Academy, 2025; FederalPay.org, 2024). This is shown in Table 3. Over five years, that estimate totals about $37.5 million. The estimates for flight instructors are based on their hourly wage of $43, with each student required to train for about ten hours in the cockpit alongside an instructor; approximately 1660 students complete NIFE each year (ZipRecruiter, 2025). The operating costs for the Cessna are around $125 an hour, which leads to total annual operating costs of $ 2 million, calculated from 1,660 students each completing ten hours in the cockpit (Epic Flight Academy, 2025). Lastly, a general estimate suggests that 25 GS-13 instructors are needed to cover the academic portion of NIFE, with a base salary of $100,000 per year (FederalPay.org, 2024).

Table 3. Cost for NIFE to be Conducted Fully in House

Item	Description	Cost over 5 Years	Annualized
Flight Instructors	To fly and teach alongside students in the cockpit	$3.57 Million	$713,800
Cessna 172 Fleet	Plane used to teach students in NIFE	$10 Million	$2 Million
NIFE Academic Teachers	25 GS-13 Level Employees	$12.5 Million	$2.5 Million
Total		$26 Million	$5.2 Million

Source (from top to bottom): ZipRecruiter (2025); Epic Flight Academy (2025); FederalPay.org (2024).

C. ANALYSIS

This analysis discusses the cost breakdown from Tables 1, 2, and 3. It assumes that all NIFE students will use the same AI technologies and defines both the costs and intangible benefits of integrating artificial intelligence into the NIFE curriculum.

1. Assumptions

This CBA examines the possibility of replacing the entire NIFE curriculum with AI with the assistance of some supporting staff. The analysis assumes that all students would be taught the complete NIFE curriculum through artificial intelligence tutoring tools, such as the TakeFlight Interactive simulator while being overseen by certain staff members. As mentioned in the literature review, students who participated in mandatory

AI-enhanced simulator training outperformed their peers in the legacy curriculum (NAWCTSD, 2022). This leads to a conclusion that AI would significantly benefit students, particularly during their flights in a simulated environment with AI assistance. Based on our literature review, students were better prepared for the later stages of flight school when completing the curriculum in a simulator (NAWCTSD, 2022). Assuming the performance increase is accurate, this study proposes replacing the entire NIFE curriculum with AI and simulators for the CBA. The estimate for a basic artificially intelligent tutor originates from a Stanford experiment, which demonstrated notable improvements in student academic performance (Toppo, 2024). Students would navigate the academic portion independently using an artificial intelligence tutoring tool that tracks their progress and success in grasping the material. The proposed analysis also assumes that the flights required for completing NIFE would be conducted through artificial intelligence simulators that evaluate and assess the skills of the student pilot. To ensure course flow and assist students with simulator use, GS-13 staff would still be needed, even if AI were to replace the current curriculum.

2. Cost Benefits

There were three scenarios considered in regard to conducting NIFE.

- Replacing the entire curriculum with AI (Table 1)
- Contracting the program to a private company (Table 2)
- Conducting NIFE through Navy's own resources (Table 3).

Currently, the Navy has contracted NIFE out to a civilian company, with the total cost per year being approximately $5 million. As proposed, if the Navy adopted a complete curriculum based in AI with the assistance of a few staff members, it would cost approximately $2.95 million a year. This would allow the Navy to save an estimated $2 million annually and approximately $10 million over five years. The savings and benefits of this scenario are reflected in Table 4.

On the other hand, if the Navy decided to utilize its own resources and equipment for NIFE, the annual cost would be nearly $5.2 million. Transitioning to a fully artificial intelligence-based system could save the Navy an estimated $2.2 million each year in this scenario. The savings in this scenario are also reflected in Table 4.

3. Intangible Benefits

A problem that continues to plague flight students and the NIFE curriculum is the weather. Certain conditions are necessary for flying, and even stricter conditions apply for new student pilots for obvious reasons. As the weather is unpredictable and unchanging, the number of canceled flights would decrease if the mandatory flights were conducted in the simulator. This change would allow students to progress through the curriculum at a consistent rate. It would also create a more streamlined schedule for both students and the administrative staff as they work to schedule 140 students and their flights each month. Without wasting time waiting for the weather to clear, students can move efficiently through NIFE and prepare for the next stage of flight school.

The students can also work through a curriculum designed for them if NIFE transitions to being conducted through artificial intelligence. They will have 24/7 access to the material, as it will be available digitally. This type of learning provides students the opportunity not only to understand but also to master the necessary information to complete NIFE. The benefit of receiving instruction tailored to each student is a crucial enhancement to the pilot's ability to serve the United States.

Using AI will provide the Navy with the opportunity to collect data on student pilots. This data is essential for identifying weaknesses in the curriculum and assessing pilot performance. Understanding the demographics and challenges of different pilots can help administrators adjust the curriculum and pinpoint areas where specific students may require more support and training than others.

4. Alternative Considerations

While this study concludes that replacing NIFE 2 with AI would be cost-effective, it is possible that this analysis is flawed. Several reasons may support this. Given the rapid advancement of AI technology, the costs of keeping up with technological improvements might become substantial enough over time to negate the cost benefits of implementing AI.

Furthermore, the impact of eliminating all introductory live flights may be evident in Primary. Additional financial resources may need to be allocated to Primary in order to address the fact that most SNAs have no flight experience until they reach Primary. Lastly, because the adoption of AI tools is relatively new within the Naval aviation community, there may be barriers or hesitation from both students and instructors in using these tools, which could affect usage and curriculum efficiency.

D. SUMMARY

Table 4 shows the total cost per method of conducting NIFE, including notes on each method, as a result of the cost benefit analysis. This study finds that replacing NIFE 2 with AI would be cost beneficial, saving more than $10 million over five years.

Table 4. Total Costs per Method of Conducting NIFE 2

Method	Cost Over 5 Years	Annualized Cost	Notes
AI Implementation	$14.8 Million	$2.95 Million	Cheapest over five years, with high initial costs. Savings is estimated to be worth more than $10 million over five years.
NIFE Contract (Current)	$25 Million	$5 Million	Alleviates the need for the Navy to utilize crucial manpower by outsourcing it.
Navy in House	$26.1 Million	$5.2 Million	The most expensive option, but all of the work is completed by the United States Navy.

The Navy has several options to consider regarding how NIFE 2 is conducted. Currently, the cost to contract NIFE 2 is comparable to the cost of conducting this training entirely in-house, utilizing Naval manpower, equipment, and other resources. Considering the findings from the literature review, this CBA assumes that replacing the current NIFE 2 curriculum with AI and simulators would not negatively impact SNA performance. This approach would eliminate the potential for weather and maintenance delays, yield savings of $10 million over five years, and provide intangible benefits to students, instructors, and the curriculum as a whole. Table 4 summarizes the costs, advantages and disadvantages for the three options considered.

Table 5. Advantages and Disadvantages

Method	Advantages	Disadvantages
AI Implementation	Saves the Navy millions of dollars in the long run.	An AI simulator is good, but nothing better prepares a pilot than sitting in the actual cockpit of a plane.
NIFE Contract (Current)	Alleviates manpower duties for the Navy to support NIFE.	The curriculum is being taught by people outside the military and is more expensive.
Navy in House	Curriculum is being taught directly by military personnel.	More expensive than the other options and requires manpower from the Navy.

VI. FINDINGS AND DISCUSSION

Part A of this chapter highlights relevant findings from the research conducted in this study. Part B delves into a discussion of these findings.

A. FINDINGS

This section highlights the key findings from this research on the topics of NIFE, aviation in both military and civilian sectors, education, and the application of artificial intelligence in education, industry, and aviation. This section also notes additional findings and discussions regarding the costs and benefits of AI implementation in NIFE.

1. Limitations of NIFE

The NIFE training phase presents several inefficiencies that hinder student progression and increase resource strain. NIFE serves as the academic and introductory flight phase for student aviators, designed to prepare them for the rigors of Primary and Advanced training (U.S. Navy, 2022). While NIFE 1 offers SNAs necessary education on the academic basics of flying, the necessity of NIFE 2 is more contentious. The flight phase of NIFE is burdened by expanding wait times between the academic and flight training phases. The program is taking almost twice as long as scheduled (Freedman & Johnson, 2024). Additionally, reliance on contracted aircraft and civilian instructor pilots (CIPs) in NIFE 2 incurs high operational costs and remains vulnerable to external delays, such as weather and maintenance issues, which can delay students for days or weeks. These wait periods contribute to training delays and are related to elevated attrition in follow-on Primary training (Lambert, 2022). NIFE 2 not only suffers from training delays, but the training value of NIFE 2 equates to about 2.4 visual flight rules events in Primary (Freedman & Johnson, 2024). Essentially, it can take students up to ten weeks to complete all seven flights of NIFE 2 (see Appendix B), which could be completed in less than 3 flights in a military aircraft during Primary. These factors contribute to pipeline backlogs and limit the Navy's ability to produce mission-ready aviators efficiently (Brophy & Chomic, 2024).

2. Operational Benefits of AI

The benefits of using AI to optimize processes is seen across industry and education alike. For flight education, AI can provide significant operational advantages in tutoring and scheduling. and feedback.

3. Tutoring

Multiple studies have found that an ITS can achieve effectiveness comparable to human tutoring. VanLehn (2011) discovered that, while human tutoring had an effect size of d=0.79, the effect size of an ITS was highly competitive, reaching d=0.76. Another study revealed that ITS significantly outperformed large-group instruction, computer-based learning, and textbook use (Ma, 2017). AI-powered tutoring systems can provide personalized academic support to student aviators (Fitria, 2021). These systems adaptively modify lesson content based on individual learning patterns, performance, and comprehension while promoting student engagement. Both civilian education platforms and military training environments demonstrate that adaptive AI tutors can markedly enhance student retention and decrease the amount of time spent on classroom instruction (Forcier et al., 2016). Within NIFE, such tools could be integrated into the academic phase to better prepare students before entering simulators or aircraft.

4. Scheduling

AI systems can create optimal training schedules by automatically aligning students, instructors, simulators, and aircraft, and by evaluating availability, performance history, and resource constraints rather than relying on manual coordination. AI systems can help minimize downtime, reduce bottlenecks, and increase throughput. The U.S. Air Force and MIT developed an AI-assisted plugin for the C-17 scheduling tool, Puckboard. This plugin automates the scheduling of aircrews while considering operational constraints (Foy, 2021). This innovation improved the scheduling process and could serve as a model for other applications in Navy training environments. Through the effective use of AI, a more efficient schedule can be created, eliminating the manpower needed to produce flight schedules and minimizing wasted resources.

5. Feedback

AI-enabled feedback systems provide students with real-time, actionable insights into their performance on the simulator. The Naval Air Warfare Center Training Systems Division found that students who used the AI-based virtual instructor VIPER during VR practice achieved a higher overall raw event score during Primary (Naval Air Warfare Center Training Systems Division [NAWCTSD], 2022). Not only this, but the majority of students who utilized the virtual instructor also felt better prepared for their flights, which aided their confidence and motivation. Using feedback systems like a virtual instructor can reduce delays and inconsistencies associated with human feedback, allowing students to correct errors immediately and learn more efficiently. In the context of flight simulators, systems such as TakeFlight's AIVIator can provide objective assessments after each repetition, creating a loop of continuous improvement even without instructor intervention (Hafer et al., 2019; TakeFlight Interactive, 2023).

6. Cost

The cost differential between traditional and AI-assisted training is substantial. Training a fully qualified Navy fighter pilot—by the end of advanced training—costs nearly $10 million, and attrition during advanced stages results in losses of approximately $2 million per student (Prasad-Rao et al., 2023). AI-driven simulators and personalized instruction provide an opportunity to reduce costs by decreasing the need for contracted flights and instructors, enhancing student preparedness, and identifying those at risk before they reach expensive late-stage flight phases, yielding considerable long-term financial benefits. The cost-benefit analysis of this study concluded that if the current NIFE curriculum were to be completely replaced by AI tools, it would save $10 million over five years. When combined with academic and operational gains, these financial advantages underscore the broader strategic value of AI adoption in naval flight training.

B. DISCUSSION

Given the findings of this research, it is crucial to discuss the potential impact AI may have on the Naval aviation training syllabus and examine what the implementation of this technology might entail.

1. Benefits of AI in Naval Aviation Training

The findings of this research suggest that AI can be beneficial when integrated into NIFE, beyond just cost savings. Benefits include personalized learning, intelligent tutoring, and efficiency gains for both instructors and the curriculum as a whole. This section further discusses these benefits and their impacts.

2. Personalized Learning and Intelligent Tutoring

Most aviation training requires practice, feedback, and repetition. This occurs in an academic setting, where students are tested on weather, aerodynamics, engines, and other essential foundational topics (See Appendix A-1). Practice is also necessary for flights, where students demonstrate procedural maneuvers and techniques. Assisted learning tools utilizing various AI technologies could aid students in this practice, reducing reliance on instructors. Instead of all students studying their material uniformly, Intelligent Tutoring Systems (ITS) can customize teaching methods for each individual learner. This can help maximize efficiency in SNA studying while also aiding students in achieving retention and understanding in a way that suits them best. Moreover, if an ITS is available to SNAs during their transitions between training phases, they can utilize this tool during extended waiting periods to maintain proficiency in the material they have just mastered.

When it comes to flying, AI-based virtual instructors have proven beneficial to SNAs when paired with VR simulators. Programs like VIPER or TakeFlight's AIVIator help students get the reps and sets they need to step into the cockpit confidently and prepared. Similar to an ITS, AI instructors can provide students with immediate and personalized feedback on their training. This allows each SNA the opportunity to fine-tune their skills at their own discretion. Additionally, instead of relying on self-correction or assessment, students can focus on building muscle memory while the AI Instructor provides necessary feedback.

Whether used voluntarily or included in the syllabus, AI learning tools can provide significant benefits for SNA learning both inside and outside the cockpit, leading to more confident and motivated student pilots.

3. Efficiency Gain for Instructors and Curriculum

With backups affecting the Naval aviation community, it is beneficial to implement systems that can streamline the training pipeline. AI technologies can assist with this. There are several avenues where this can take place. To enhance the curriculum's efficiency, AI-based virtual instructors paired with simulators can supplement or even replace NIFE 2 flights. Students can practice their maneuvers in the simulator, receiving feedback from their AI instructor as they strive to achieve a proficient score. Instead of completing the six flights and one check ride (See Appendix B), students could perform a common practice 'warm-up' flight, exercise their skills in the simulator with an AI instructor, and fly a final check ride once they have demonstrated proficiency in the simulator. This approach would enable students to hone their skills and gain some experience in the air while minimizing delays due to weather, maintenance, or staffing issues.

AI tools can provide significant efficiency benefits for instructors as well. AI technologies can be utilized to grade and offer feedback to students on their academic exams. This assists both students and instructors, relieving instructors of certain responsibilities while providing students with guided feedback to address or identify shortcomings. Similar technologies can also be applied to create flight schedules, not only alleviating another instructor duty but also generating an optimized schedule based on available resources and demand.

AI technologies can also be used to provide more effective instruction to students. AI-based instructors can replace military instructors in simulators. This is greatly beneficial for both instructors and students. By reducing the need for instructors to give feedback during simulated flights, they can be more available on an as-needed basis, or to oversee and verify students ready to validate specific skills in the simulator. For students, an AI-based instructor offers personalized feedback focused on one student, rather than a military instructor overseeing a group.

These efficiency gains for instructors and the curriculum help to alleviate the pressure of delays in the pipeline while also representing a better use of resources. AI technologies are beneficial for student learning, instructor commitments, and the naval aviation training curriculum as a whole.

C. CHALLENGES AND LIMITATIONS

Despite the discussed benefits and advantages, there are foreseeable challenges and limitations to implementing AI into the naval aviation training curriculum.

1. Evaluation and Assessment Issues

Without standardized and effective evaluation and assessment parameters, AI teaching tools could be misleading or ineffective. To use AI tools for guiding SNAs to a specific skill level, AI instructors must be programmed to coach toward this standard. However, current systems like VIPER struggle to recognize that flight maneuvers can be performed in more than one correct way (Naval Air Warfare Center Training Systems Division [NAWCTSD], 2022). This false negative error can lead to student frustration, confusion, and mistrust in the technology, diminishing its impact on student learning. Furthermore, due to the nascent stage of this technology, it has not yet developed normed grading models (Naval Air Warfare Center Training Systems Division [NAWCTSD], 2022). Inconsistencies in feedback means that some students are held to a higher standard than others, failing to acknowledge incorrect inputs, or mistakenly correcting positive inputs all undermine the trust and effectiveness of AI tools (Naval Air Warfare Center Training Systems Division [NAWCTSD], 2022).

In order to use AI tools to aid in verifying or validating SNA skill level, the technology will need further development and testing until it is consistently reliable.

2. Risk of Over Reliance and Technical Gaps

One of the most pressing concerns associated with the early adoption of AI in naval aviation training is the potential over-reliance on automated systems at the expense of foundational human learning and decision-making (Flores, 2019). While AI-based tools can accelerate learning, they may also degrade critical thinking and manual flying skills if not balanced with live instruction (Zilai, 2016). SNAs are particularly susceptible to over-reliance when practicing in an ideal AI environment. Due to their lack of experience in the air, students who primarily learn with AI tools can become overconfident and miss essential lessons in resilience or adaptability that they would acquire through live flight.

Technical gaps in AI-driven tools present additional reasons for caution. At an industry level, AI tools are constrained by their scenario complexity, adaptability, and hardware reliability. The aviation community is experiencing similar challenges. The VIPER system faced crashes and program issues that negatively affected students' reception of the tool (Naval Air Warfare Center Training Systems Division [NAWCTSD], 2022). If these tools are utilized with the belief that they accurately simulate real-world flying, pilot shortcomings and blind spots may remain undiscovered.

While AI holds promising potential for Naval flight education, these advantages must be approached with critical oversight. Human instructors, live flight events, and well-designed metrics should remain the primary focus of training to reduce the risks of automation complacency and technology gaps.

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VII. CONCLUSION AND AREAS FOR FUTURE RESEARCH

The purpose of this study was to utilize existing materials to evaluate the potential impact that artificial intelligence could have if implemented into naval flight training. This study concentrated on the early stages of the training pipeline, emphasizing NIFE. In this chapter, Part A revisits the primary and supporting questions and presents the conclusions of this study. Part B suggests areas for future research.

A. CONCLUSION

This study examined sources related to the Naval aviation training pipeline, AI in aviation, and artificial intelligence in education. This research aimed to answer six questions regarding the theoretical impact of AI on naval aviation training. The primary question investigated was:

1. How can AI technologies assist learning in naval flight training to maximize the effectiveness and efficiency of flight training while reducing the current backlog?

This study finds that AI technologies, such as ITS and AI-based instructors, can enhance student learning and make the curriculum more effective in terms of cost and time. It is demonstrated that these AI tools can perform at a level nearly equivalent to humans or live events, but at a lower cost and with reduced susceptibility to delays. Consequently, the study concludes that integrating AI into NIFE would lead to comparable pilot performance while lowering operational costs and minimizing the time required to complete the phase.

The following supporting questions were utilized to guide the research of this study. The supporting questions were:

2. In what ways is artificial intelligence leveraged in education to facilitate learning?

This study finds that ITS have been utilized in education to create a personalized learning experience for students. This tool has proven to be comparable to one-on-one tutoring. An ITS enables any student to access effective learning.

3. Can AI tools be used to enhance simulator training for pilots?

This study finds that AI tools are being used to enhance simulator training. Moreover, it is found that students who used AI-based instructors during simulator sessions performed better and felt more prepared for actual flights than those who did not utilize AI.

4. Would implementing AI into Naval Introductory Flight Evaluation be cost effective?

This study finds that replacing NIFE 2 with AI would be cost-effective if implemented properly. The cost savings from replacing NIFE 2 with AI are estimated to be $10 million over five years. These potential cost savings could be significant, as a portion of the costs associated with implementing AI arises from the initial infrastructure investments necessary to execute the curriculum with AI. The savings calculated were based on a limited timeframe of only five years. With correct implementation and as the technology improves, the DoD has the opportunity to maximize its use of AI tools to train the next generation of pilots.

5. What are the potential limitations and risks of incorporating artificial intelligence into flight school?

This study finds that there are major limitations in technology reliability and assessment capabilities. The AI tools tested in naval aviation training have encountered technical issues and lack norm-based standards. These limitations could allow a student pilot's shortcomings to go unnoticed. This study concludes that this risk, paired with the risk of over-reliance, is significant enough to emphasize the need for further development in the technology before it is fully adopted.

6. How can artificial intelligence help mitigate delays in NIFE?

This study finds that the most significant way for AI to help mitigate delays is by replacing NIFE 2 flights with AI-instructed simulator flights. Doing so would eliminate the risk of significant weather and maintenance delays disrupting NIFE 2.

To examine the potential financial impact of AI, a preliminary cost-benefit analysis was conducted using a combination of estimates, contracts, and recent data on the costs of NIFE and AI tools. This study highlighted the limitations of NIFE and found that AI offers potential operational benefits for student learning and curriculum efficiency. Despite these benefits, this study also indicates that shortcomings in technology development and over-reliance could adversely affect pilot performance. Follow-up research should be conducted to aid in developing, validating, and implementing effective and reliable AI-driven tools in naval aviation training.

B. AREAS FOR FUTURE RESEARCH

To effectively implement AI in Naval aviation training, further research is necessary to complete the development, validation, and proper application of AI learning tools. Three areas of future research are discussed below, each of which could aid in the development, validation, or application of AI tools.

1. Developing Norm-Referenced AI Performance Metrics

The findings of this study suggest that AI-based learning tools could greatly benefit student learning and enhance curriculum efficiency. However, as flight training programs like Project Avenger continue to evolve, a significant area that needs further investigation is the development of validated, norm-referenced performance metrics. Current AI-based training systems lack the statistical depth necessary to evaluate student progress or pipeline competitiveness. Future research should focus on developing performance models that account for maneuver complexity, learning curves, and advanced cognitive skills. These models should be validated against student outcomes in advanced training phases and in operational environments to ensure the model accuracy. Follow-on studies could evaluate how early AI-based scores correlate with later fleet performance, providing the necessary evidence to support or refine AI scoring systems.

2. AI Feedback vs. Instructor Feedback

Another important area for future study is the impact of AI-generated feedback and human instructor feedback on student learning, confidence, and retention. AI tutors and simulators provide students with immediate, consistent, and data focused. However, it isn't clear if students receive and apply AI feedback differently when compared to feedback received from experienced flight instructors. Human flight instructors earn the respect and trust of student pilots through relationships, allowing for the opportunity to incorporate mentorship and operational context into their instruction. Future research should difference in response to AI-generated versus human-generated feedback. Research should focus on less measurable areas, such as judgment and situational awareness. Research that combines performance data with qualitative interviews or surveys could provide insights into student trust, perceived fairness, and emotional responses to AI-generated feedback.

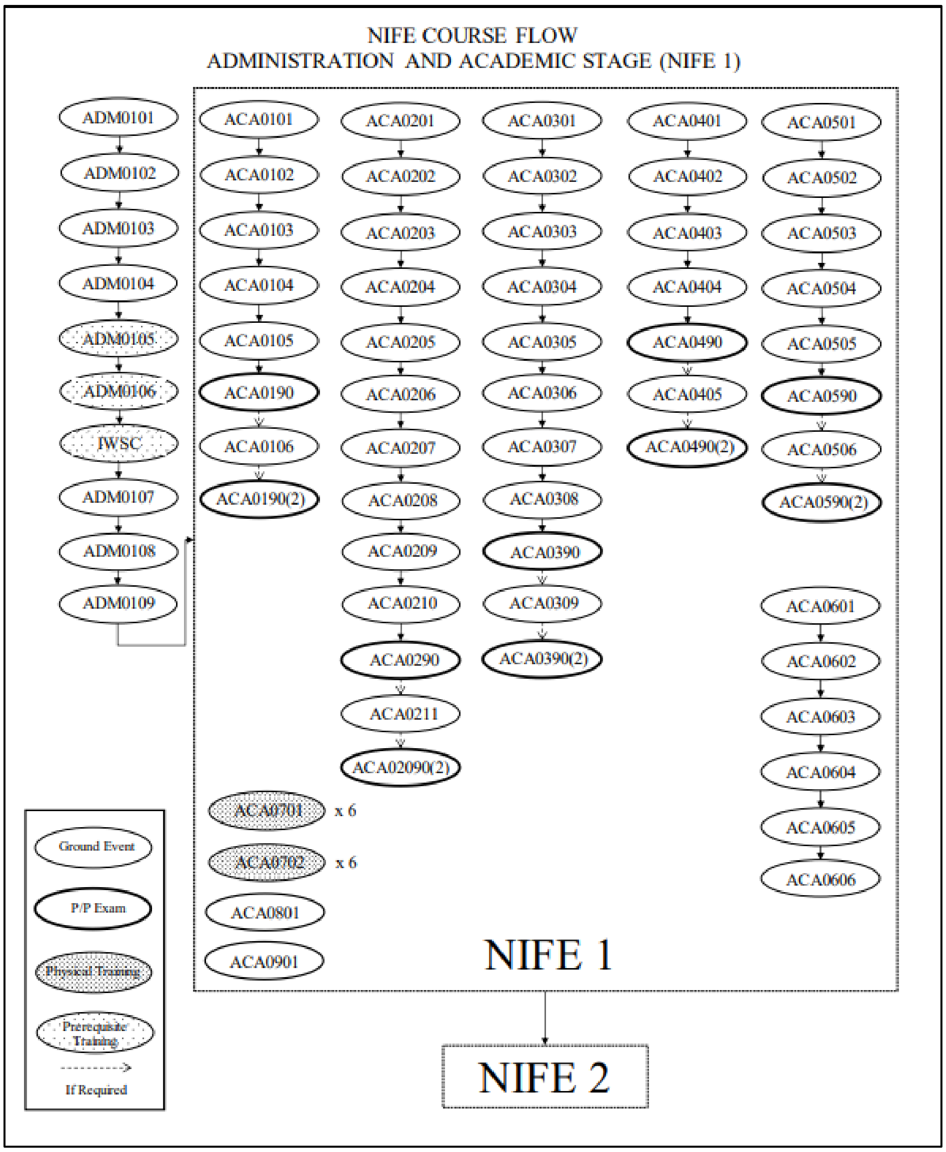
3. Implementation of AI Throughout Entire Pipeline

This study focused on the use of AI in the early stages of naval aviation training. Future research should explore the potential for AI integration throughout the entire training pipeline. Future research should identify opportunities for AI to support increasingly complex flight training objectives. Skills such as formation flying, night operations, and carrier qualifications should be evaluated for potential AI application. Other areas of study should include areas like mission planning, adaptive stress exposure, and debrief analysis. Evaluating the cumulative impact of AI-based instruction across a full student naval aviator training timeline will be critical for understanding AI's long-term value and identifying where human expertise must remain dominant.

APPENDIX. NIFE COURSE FLOW AND ACADEMIC TRAINING

The NIFE course flow includes two parts: NIFE 1 and NIFE 2. NIFE 1 includes administration and academic events. NIFE 2 includes a mix of ground and flying events.

a. NIFE 1 Course Flow



Academic (ACA), Administration (ADM), Intermediate Water Survival Course (IWSC).
Source: NASCINST (2023)

b. *NIFE 1 Academic Events*

Ethics (ACA0801)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA08	Class	Ethics	1	2	ETH

1. Prerequisites. None.

2. Events

ACA0801	Lect	Ethics	2.0

3. Syllabus Notes. None.

Academic (ACA). Source: NASCINST (2023).

Physical Fitness (ACA07XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA07	Class	Physical Fitness	12	18	PT

1. Prerequisites. None.

2. Events

ACA0701	Gym	PT 1: Circuit Training	1.5
ACA0702	Gym	PT 2: Weight Training	1.5

3. Syllabus Notes. Twelve physical fitness training sessions will be scheduled throughout NIFE 1 and NIFE 2 ground school.

Academic (ACA). Source: NASCINST (2023).

Aviation History (ACA0901)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA09	Class	Aviation History	1	2	HIST

1. Prerequisites. None.

2. Events

ACA0901	Museum	Aviation History	2.0

3. Syllabus Notes. None.

Academic (ACA). Source: NASCINST (2023).

Land Survival (ACA06XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA06	Class	Land Survival	6	7	LS

1. Prerequisites. None.

2. Events

ACA0601	Lect	LS 1: Survival Medicine	1.0
ACA0602	Lect	LS 2: Signaling and Recovery	1.0
ACA0603	Lect	LS 3: Personal Protection	2.0
ACA0604	Lect	LS 4: Water Procurement	1.0
ACA0605	Lect	LS 5: Food Sources and Cooking Methods	1.0
ACA0606	Lect	LS 6: Animal Procurement, Traps and Snares	1.0

3. Syllabus Notes. None.

Academic (ACA), Land Survival (LS). Source: NASCINST (2023).

Weather (ACA05XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA05	Class	Weather	8	13	WX

1. Prerequisites. None.

2. Events

ACA0501	Lect	WX 1: Theory	2.0
ACA0502	Lect	WX 2: Mechanics	2.0
ACA0503	Lect	WX 3: Hazards	1.5
ACA0504	Lect	WX 4: Planning and Resources	2.0
ACA0505	Lect	WX Exam Review	1.5
ACA0590	P/P Exam	WX Exam	1.5
ACA0506	Lect	WX Remediation	1.0
ACA0590 (2)	P/P Exam	WX Re-Exam	1.5

3. Syllabus Notes. The minimum passing score for ACA0590 is 80%.

Academic (ACA), Weather (WX). Source: NASCINST (2023).

Flight Rules And Regulations (ACA04XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA04	Class	Flight Rules and Regulations	7	11.5	FR&R

1. Prerequisites. None.

2. Events

ACA0401	Lect	FRR 1: Federal Aviation Administration	2.5
ACA0402	Lect	FRR 2: VFR/IFR Rules	2.5
ACA0403	Lect	FRR 3: Airspace/General Flight Rules	2.0
ACA0404	Lect	FRR Exam Review	0.5
ACA0490	P/P Exam	FRR Exam	1.5
ACA0405	Lect	FRR Remediation	1.0
ACA0490 (2)	P/P Exam	FRR Re-Exam	1.5

3. Syllabus Notes

a. The minimum passing score for ACA0490 is 80%.

Academic (ACA), Flight Rules and Regulations (FRR), Instrument Flight Rules (IFR), Visual Flight Rules (VFR). Source: NASCINST (2023)

Navigation (ACA03XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA03	Class	Navigation	11	15	NAV

1. Prerequisites None.

2. Events

ACA0301	Lect	NAV 1: Introduction to Air Navigation	0.5
ACA0302	Lect	NAV 2: Chart Projection, Plotting, and Global Timekeeping	2.0
ACA0303	Lect	NAV 3: Time, Distance, and Ratio Calculations	2.0
ACA0304	Lect	NAV 4: Airspeeds	0.5
ACA0305	Lect	NAV 5: Preflight Winds	2.0
ACA0306	Lect	NAV 6: In-Flight Winds	1.0
ACA0307	Lect	NAV 7: Flight Planning and Conduct	1.0
ACA0308	Lect	NAV Exam Review	1.0
ACA0390	P/P Exam	NAV Exam	2.0
ACA0309	Lect	NAV Remediation	1.0
ACA0390 (2)	P/P Exam	NAV Re-Exam	2.0

3. Syllabus Notes

a. The minimum passing score for ACA0390 is 80%.

Academic (ACA), Navigation (NAV). Source: NASCINST (2023).

Engines (ACA02XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA02	Class	Engines	13	13.5	ENGINES

1. Prerequisites None.

2. Events

ACA0201	Lect	ENG 1: Principles of Gas Turbine/Reciprocating Operation	1.0
ACA0202	Lect	ENG 2: Gas Turbines/Reciprocating Engines	0.5
ACA0203	Lect	ENG 3: Compressor Stalls	0.5
ACA0204	Lect	ENG 4: Gas Turbines/Reciprocating Engine Types	1.0
ACA0205	Lect	ENG 5: Hydraulic Systems	1.0
ACA0206	Lect	ENG 6: Electrical Systems	0.5
ACA0207	Lect	ENG 7: Fuel Systems	1.0
ACA0208	Lect	ENG 8: Lubricants and Lubrication Systems	1.0
ACA0209	Lect	ENG 9: Accessory, Starter, and Ignition Systems	1.0
ACA0210	Lect	ENG Exam Review	1.5
ACA0290	P/P Exam	ENG Exam	1.5
ACA0211	Lect	ENG Remediation Exam	1.5
ACA0290 (2)	P/P Exam	ENG Re-Exam	1.5

3. Syllabus Notes. The minimum passing score for ACA0290 is 80%.

Academic (ACA), Engines (ENG). Source: NASCINST (2023).

Aerodynamics (ACA01XX)

Blk #	Media	Title	Events	Hrs	Blk Name
ACA01	Class	Aerodynamics	8	14.5	AERO

1. Prerequisites None.

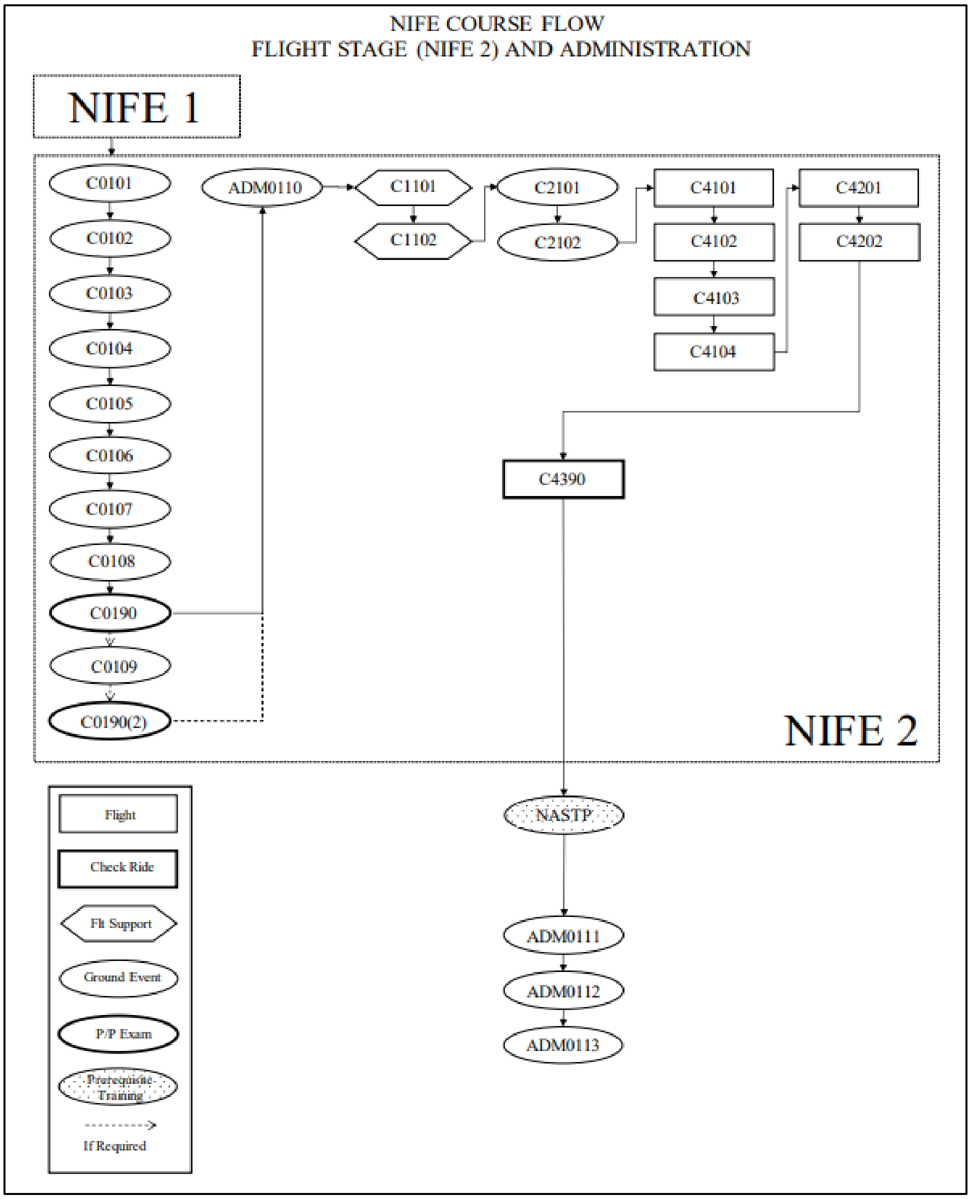
2. Events

ACA0101	Lect	AERO 1: Basic Theory and Lift Production	2.0
ACA0102	Lect	AERO 2: Drag and Stalls	2.0
ACA0103	Lect	AERO 3: Performance Characteristics	2.0
ACA0104	Lect	AERO 4: Maneuvering and Hazards	2.0
ACA0105	Lect	AERO Exam Review	2.0
ACA0190	P/P Exam	AERO Exam	2.0
ACA0106	Lect	AERO Remediation	1.0
ACA0190 (2)	P/P Exam	AERO Re-Exam	1.5

3. Syllabus Notes. The minimum passing score for ACA0190 is 80%.

Academic (ACA), Aerodynamics (AERO). Source: NASCINST (2023).

c. *NIFE 2 Course Flow*



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