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Follow-on Student Pilot Performance Differences Based on Private Pilot Training in a Residential Collegiate Program or Non-Collegiate Program

Anton William Cihak II
Florida Institute of Technology

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Anton William Cihak II

Bachelor of Science Vocational Education
Southern Illinois University – Carbondale
Carbondale, IL
1989

Master of Arts Religion
Liberty Baptist Theological Seminary
Lynchburg, VA
2003

Master of Military Art and Science
Air Command and Staff College
2004

Master of Airpower Art and Science
School of Advanced Air and Space Studies
2005

Master of Arts National Security and Strategic Studies
Naval War College
2011

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Florida Institute of Technology
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Doctor of Aviation

Melbourne, Florida
July 2021

We the undersigned committee
hereby approve the attached dissertation

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by

Anton William Cihak II

Brooke E. Wheeler, Ph.D.
Assistant Professor
College of Aeronautics
Major Advisor

Meredith Carroll, Ph.D.
Associate Professor
College of Aeronautics
Committee Member

Isaac Silver, Ph.D.
Graduate Faculty
College of Aeronautics
Committee Member

Ralph D. Kimberlin, Ph.D.
Professor
College of Engineering and Science
Committee Member

Ulreen O. McKinney, Ph.D.
Assistant Professor and Dean
College of Aeronautics

Abstract

TITLE: Follow-on Student Pilot Performance Differences Based on Private Pilot Training in a Residential Collegiate Program or Non-Collegiate Program

AUTHOR: Anton William Cihak II

MAJOR ADVISOR: Brooke Wheeler, Ph.D.

The purpose of this study was two-fold: to examine the difference between students who had obtained a private pilot certificate from a residential collegiate flight program and students who had obtained a private pilot certificate from a non-collegiate flight program in a) pilot performance and b) time spent completing commercial and instrument flight courses. A supplemental analysis of the differences in the number of lessons required to complete commercial and instrument flight training was also conducted as a further comparison between pilot groups. This study utilized an ex post facto, effects-based methodology and design with data derived from a university flight program's archived flight records spanning a five-year period. A census of the commercial and instrument student records was used to provide the following: the sum of graded lesson objectives in each course, the ground and flight hours completion for each course, and the number of lesson attempts in each course. Independent-samples *t* tests conducted on the graded activity sums indicated no significant difference between pilot groups. MANOVAs conducted on the ground and flight times within each commercial and instrument course revealed a significant difference between pilot groups in the first of three commercial pilot courses. Follow-up univariate ANOVAs further revealed a significant difference in ground instruction time required with non-collegiate trained private pilots requiring more ground instruction time than collegiate trained pilots. No other time-related significant findings between pilot groups were identified. Mann-Whitney U tests on the lesson attempts indicted a significant difference between pilot groups in the first of three commercial pilot courses with non-collegiate trained private pilots requiring more lessons than collegiate trained pilots to complete the course. Findings of this study build upon existing research and contribute to a greater understanding of collegiate flight training with a focus on improving integration of non-collegiate trained private pilots into the collegiate training environment.

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List of Abbreviations

ACS: Airman Certification Standards

ADM: Aeronautical Decision Making

AIH: Aviation Instructor's Handbook

ANOVA: Analysis of variance

CFI: Certified Flight Instructor

CITI: Collaborative Institutional Training Initiative

COVID-19: Coronavirus disease 2019

CRM: Crew Resource Management

CTP: Collegiate Trained Private Pilot

DPE: Designated Pilot Examiner

DV: Dependent Variable

FAA: Federal Aviation Administration

FIRC: Flight Instructor Refresher Course

FIT: Florida Institute of Technology

FSDO: Flight Standards District Office

FTD: Flight Training Device

GA: General Aviation

GAA: General Aviation Aircraft

GPS: Global Positioning System

IBM: International Business Machines

IRB: Institutional Review Board

IV: Independent Variable

MANOVA: Multivariate analysis of variance

MFT: My Flight Train

NCTP: Non-Collegiate Trained Private Pilot

NTSB: National Transportation Safety Board

PTS: Practical Test Standards

rMSE: Root Mean Square Errors

RPL: Required Proficiency Levels

RPL-1: Required Proficiency Level 1

RPL-2: Required Proficiency Level 2

RPL-3: Required Proficiency Level 3

RPL-4: Required Proficiency Level 4

RPL-5: Required Proficiency Level 5

SD: Standard Deviation

SIU: Southern Illinois University

SME: Subject Matter Expert

SMS: Safety Management System

SPSS: Statistical Package for the Social Sciences

SS: Sum of the Squares

TAA: Technologically Advanced Aircraft

TCO: Training Course Outline

UAS: Unmanned Aerial Systems

VPN: Virtual Private Network

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you helped me remain focused on the journey and the prize at the end. Looking forward to keeping in touch!

It's the journey, and those along the way, that matter the most!

Dedication

I dedicate this work to the people who matter the most to me and who, for the past several years, without complaining, willingly sacrificed their time with their son, husband, father, and grandfather: my family.

To my parents, Anton and Sharon; thank you for instilling in me traditional values and a work ethic that doesn't know the meaning of quitting. Both have served as the basis for a life of serving others and striving to always do my best.

To my children and their families, Dr. Heather Hewitt, her husband Jonny, their adorable young lady Chloe; Kirstie Shaffer, her husband Dr. Todd Shaffer, and their two handsome young men Benjamin and Luke; Anton Cihak, Brianne Cihak, and Joel Cihak; thank you for being ever patient and understanding these past few years as I've remained semi-isolated and somewhat absent while focused on the work presented in the following pages. I am very proud of each of you and honored to have had the privilege of watching you become the man or woman you are today. Each of you are a tremendous blessing in my life and the source of great joy in seeing who you have become and where you are going.

Finally, to my beautiful, amazing, talented, patient, serving, sacrificing, godly bride of over 35-years; when you said 'Yes' all those years ago, it was to a man who had struggled to make it through high school and who at that time, had seemingly achieved the pinnacle of his professional dreams. You encouraged and motivated me to dream bigger and grow beyond myself. In the years that followed, you faithfully served along my side as we served our country together and raised an amazing family through some very challenging and difficult times. During those years, you willingly sacrificed countless nights and weekends with your husband as he was either at work or was working on yet another college class. Eventually, those classes led to an associate degree, that led to a bachelor's degree, that led to four master's degrees, and now, a doctorate. I'm very excited and proud to see you return to pursue a master's degree (and maybe beyond) of your own. Thank you for believing in me bigger than I could have ever imagined for myself. I'm looking forward to the next 35-plus years and the untold adventures the Lord has in store for us. Whether we're flying our airplane somewhere together, relaxing on a cruise, exploring new island getaways, finding perfect beaches to hang out on, scuba diving, hiking in the mountains, etc., or just hanging out at home with the kids and grandkids, they all sound perfect to me, when I'm with you!

Chapter 1

Introduction

Purpose of Study

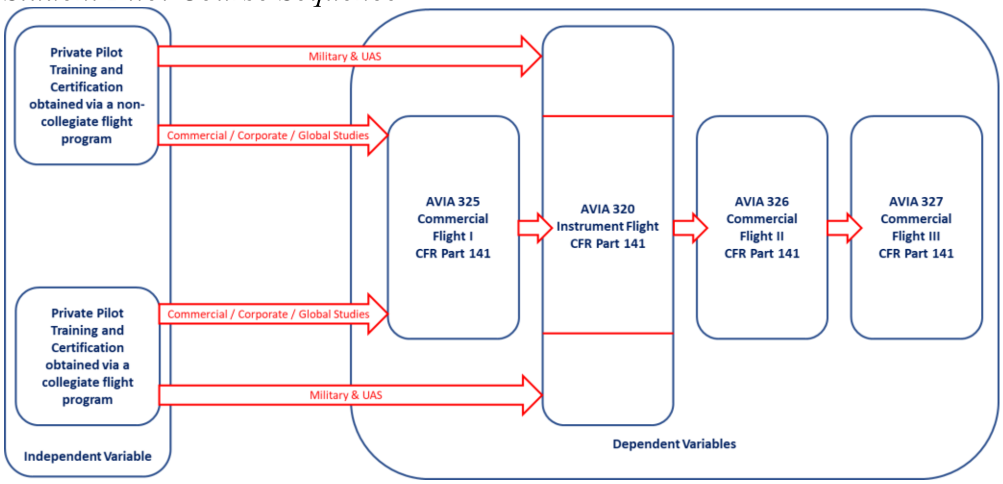
The purpose of this study was two-fold. The first purpose was to examine the difference in pilot performance in commercial and instrument flight students who obtained a private pilot certificate from a residential collegiate flight program compared to students who obtained a private pilot certificate from a non-collegiate flight program. The second purpose was to examine the difference in ground and flight time spent in completing commercial and instrument flight courses between students who obtained a private pilot certificate from a residential collegiate flight program compared to students who obtained a private pilot certificate from a non-collegiate flight program.

For purposes of the current study, pilot performance is measured by a required proficiency level (RPL) score. RPL scores were determined as the sum of the Certified Flight Instructor (CFI) assigned RPL scores for every line item in each lesson first attempt within each flight course. Two dependent variables (DV) in the current study referenced time spent: ground and flight (simulator plus aircraft) time standardized training time differences from flight course minima. Ground and flight time were determined as the difference in time (ground and flight, respectively), to the nearest tenth of an hour, between the amount of time (ground and flight, respectively) required for successful completion of each flight course and the minimum time (ground and flight, respectively) required by the applicable training course outline (TCO) including repeated or additional lessons.

Background and Rationale

The focus of the proposed study was a large Mid-Atlantic region collegiate flight program with accredited aeronautics bachelor's degrees authorized by the Federal Aviation Administration (FAA) to provide CFR Part 141 certified and regulated ground, simulator, and flight training. At the time of this study, the flight school offered CFR Part 141 instruction toward a private pilot single-engine land certificate, an instrument rating, and a commercial pilot single-engine land certificate to collegiate students in pursuit of a Bachelor of Science Degree in Aeronautics. Each certificate or rating program was regulated and administered by an FAA designated chief flight instructor and several assistant chief flight instructors through an FAA approved and mandated training course outline (TCO) specified and approved for each course by the local flight standards district office (FSDO). Figure 1.1 provides a graphic representation of student pilot course sequence through the commercial, corporate, military, global studies, and Unmanned Aerial Systems (UAS) degree programs.

Figure 1.1
Student Pilot Course Sequence



Note: Although students may have been enrolled in one of the four degree completion plans, all students flow through the flight courses along one of two paths beginning with either collegiate private pilot training or non-collegiate private pilot training.

Each TCO was designed with specific training standards to prepare flight students to meet or exceed applicable FAA standards for each pilot certificate or rating as specified and regulated by the FAA through the Practical Test Standards (PTS) or Airman Certification Standards (ACS) for each certificate or rating. Specifically, the Commercial Pilot TCO training standards were designed to prepare flight students to meet or exceed the standards specified by the FAA in the Commercial Pilot PTS (2011) or ACS (2018). Similarly, the Instrument Pilot TCO training standards were designed to prepare flight students to meet or exceed the standards specified by the FAA in the Instrument Pilot PTS (2013) or ACS (2018).

Student progression through each CFR Part 141 course was individually assessed by CFR Part 141 trained and certified staff Certified Flight Instructors (CFIs) and monitored by a Chief Instructor Pilot using the respective TCO as the measurement instrument and performance standard that was appropriate for each course. Specifically, the Commercial Pilot TCO was used as the commercial pilot measurement instrument and performance standard for the commercial pilot courses AVIA 325, AVIA 326, and AVIA 327. The Instrument Pilot TCO was used as the instrument pilot measurement instrument and performance standard for the instrument pilot course. CFIs recorded student performance within each course and respective TCO through the flight management program and FAA approved system of record, My Flight Train (MFT). Within each TCO, each training unit (lesson) provided specific guidance and parameters that included elements such as the training media, planned lesson time, lesson prerequisites, knowledge objectives for ground lessons, simulator / flight training objectives / tasks with specific required proficiency levels, completions standards, and homework assignments for the subsequent lesson. Training media may have included associated training equipment or facilities requirements, such as a flight briefing room, a flight simulator, and / or a training aircraft. Planned lesson time included allotted time for every aspect associated with the lesson including preflight briefing time, aircraft / simulator flight time, and postflight debriefing time. Lesson prerequisites included any administrative actions needed prior to the lesson (e.g., course enrollment by the chief instructor), completion of any ground, simulator, or flight lesson required by the TCO, and any previously assigned homework for the specific lesson. Knowledge objectives for the Instrument Rating TCO and Commercial Pilot TCO are provided in Appendix A and B, respectively. Additionally, common student flight-training unit tasks were identified for each TCO (Instrument and Commercial) and are provided in Appendix C and D, respectively.

Simulator and flight training objectives / tasks were specified in each lesson and included specific Required Proficiency Levels (RPLs) for each line item. RPLs were approved by the FAA and defined within each TCO utilized by the university. Proficiency levels described in each TCO directly supported each TCO grading strategy and provided continuity and reliability in the instructor's evaluation of student performance. Each TCO unit consisted of a set number of training elements, referred to as 'line items'. Each line item was assigned a specific proficiency requirement. Proficiency levels were graded on a 5-point scale with a detailed explanation of each RPL provided in Chapter Three of this document.

To ensure continuity and reliability in training and evaluation within each TCO, as a part of the hiring and indoctrination process, each CFI was initially trained and certified by the Chief Instructor Pilot (or his / her representative) on each TCO required maneuver and the grading process to objectively evaluate student performance based on each TCO line item RPL. Additionally, each flight instructor was annually evaluated and recertified by the Chief Instructor Pilot or his / her representative to provide instruction in accordance with the TCO requirements.

To facilitate and maximize the learning environment for every student, the training environment and resources were specified and standardized in accordance with each TCO. Each of the 20 flight briefing rooms available for pre- and post-flight briefings and ground lessons were standardized and provided a distraction free learning environment. The Flight Training Devices (FTDs) used for simulator training approved within each TCO were inspected daily and certified as having met training requirements that supported each TCO as specified and directed by the FAA. If a flight training device did not meet the requirements for training use and certification, that training device was made unavailable for student training until the applicable repairs could be completed and the device recertified. All FTDs utilized by the collegiate program were FRASCA produced FTDs. Available FTDs included three FRASCA C-172 Level D FTDs, one FRASCA PA-44 Level D FTD, and seven FRASCA Reprogrammable Training Devices (RTDs). Each training device was equipped with a Garmin G1000 avionics suite designed to replicate the fleet of training aircraft operated by the flight school. The aircraft owned and operated by the flight school included 20 Cessna C-172 SP (Skyhawk) aircraft and 5 Piper PA-44 (Seminole) aircraft. Within each aircraft category (i.e., single-engine land and multi-engine land), each aircraft configuration was standardized and included a Garmin G1000 avionics suite with an integrated Garmin GFC700 autopilot system.

Anecdotal evidence through personal observation indicated that approximately 33% of new students, who began pursuit of their bachelor's degree with the host school, had obtained a private pilot certificate prior to arriving at the flight school. Again anecdotally, the majority of the students, who arrived at the host school after having already obtained a private pilot certificate, obtained that certificate through a non-collegiate flight training program. Additionally, students, who held a private pilot certificate prior to beginning flight training at the host university, had completed their private pilot training utilizing older model general aviation aircraft typically equipped with analog (traditional six-pack) instrumentation. The most common flight training aircraft used in the world include the American Champion Citabria, Cessna 150 / 152, Cessna 172, Cirrus SR20 / SR22, Diamond DA 20, Flight Designs CRLS, Piper Cherokee / Warrior, Piper Cub, Van's RV-12 (Training Aircraft Review, 2016). At the time of this study, there were registered in the United States 453 American Champion Citabria aircraft, 8,237 Cessna 150s, 1,767 Cessna 152s, 20,063 Cessna 172s, 938 SR20s, 4,727 Cirrus SR22s, 295 Diamond DA-20, 357 Flight Design CRLSs, 13,435 Piper Cherokee / Warriors, 3,603 Piper Cubs, and 602 Van's RV-12 (FAA Aircraft Registry, 2020). Thus, there were 54,477 of the most popular training aircraft, in use in the United States at the time of this study, of which, 20,063 were C-172s, the same make and model as the aircraft used by the host university. As such, it was likely that approximately 37% of the students, who arrived at the host university, after having already obtained their private pilot certificate, had received that previous training in a similar make and model aircraft as the aircraft used by the host university. Furthermore, with the rapid development of advanced technology in general aviation aircraft and primary flight training aircraft such as those highlighted above, the majority of flight training aircraft used in the United States were equipped with analog (traditional six-pack) instrumentation or a hybrid combination of analog / digital instrumentation and not one of the approximately 16,000 Garmin G1000 technologically advanced avionics suites in use at the time of this study and used exclusively by the host university in their training aircraft fleet (Haines, 2017).

Given the differences in training methodology, environment, and equipment, students who arrived at the flight school after having already been certified as private pilots may have required additional training or time to adapt and adjust to the highly structured, time-constrained collegiate flight training environment that utilized a modern fleet of Technologically Advanced Aircraft (TAA). Those same students who had previously experienced the emotional and psychological benefits associated with personal academic and practical success in obtaining a private pilot certificate, may have been overwhelmed with the fast pace, highly regimented, and technologically advanced training environment. Furthermore, students, who had previously experienced a less structured training environment typically associated with non-collegiate flight programs or trained in a less technologically advanced aircraft fleet, may have exhibited less dependence on advanced aircraft systems and may have had a better developed sense of the Aeronautical Decision Making (ADM) process. This better developed ADM process may have improved demonstrated performance in managing the more complex, less defined scenarios and situations associated with commercial instrument flight operations, but this increased level of ADM may have been insufficient to compensate for the lack of a highly developed and defined flight training program and environment, such as that found in a residential collegiate flight program. Furthermore, although non-collegiate private pilot flight training was regulated by the FAA, non-collegiate private pilot flight training was generally less regulated and standardized than residential collegiate flight training programs. Specifically, non-collegiate private pilot flight training commonly provided flight instruction under CFR Part 61 flight training regulations and provided a generalized set of flight training requirements and standards suitable for every situation and flight training environment found within the continental United States. Although the generalized flight training requirements prescribed within CFR Part 61 were adequate for local flight instructors and students to effectively conduct flight training to prepare the flight student to meet the appropriate PTS or ACS, CFR Part 61 requirements lacked the benefits of a locally developed and structured training program that maximized student learning in the local area where flight training occurred. Additionally, students who participated in non-collegiate private pilot flight training may have received flight instruction from CFIs with a wide range of instructional experience, recency, and proficiency. Students who participated in residential collegiate flight training may have also received flight instruction from CFIs with a wide range of instructional experience. But when non-collegiate flight program and residential collegiate flight program CFIs are compared against each other, differences in recency and proficiency requirements for each category of instructor may be noted when considering instructional effectiveness. Specifically, a non-collegiate flight program CFI was required to conduct a biennial Flight Instructor Refresher Course (FIRC). The FIRC requirement may have been completed either in person or via an approved online course of instruction. In most instances, a CFI may have completed the required biennial training and successfully passed either a series of in-course examinations or a single end-of-course examination in order to have renewed their CFI certificate. No additional or other training was required for the CFI to renew their CFI certificate and continue flight instruction. However, a residential collegiate flight program CFI operating under CFR Part 141 must receive initial ground and flight training and pass a ground and flight certification examination from the FAA designated Chief Instructor or his / her designated representative in each TCO prior to being allowed to instruct any student in the flight training program. Additionally, a residential collegiate flight program CFI must undergo an annual ground and flight re-evaluation by the Chief Instructor or his / her designated representative in order to continue to provide instruction in the applicable flight training program. Therefore, although a non-collegiate flight program student may have received adequate flight training within the FAA standards and requirements, a residential collegiate flight program student was assured that the instruction received in a residential collegiate flight training program was provided by a CFI who was experienced and had demonstrated recent proficiency in the course and maneuvers.

Although there appeared to have been ample prior research that examined variances between CFR Part 61 flight training and CFR Part 141 flight training programs, such literature focused primarily on identification of safety, financial, or time differences. For example, Knecht and Smith (2012) found no difference in General Aviation (GA) accident rates for private pilots who trained in CFR Part 61 programs and those who trained in CFR Part 141 programs. Arch (2007) examined the reduced time requirements and thereby the likely reduced cost and increased appeal CFR Part 141 programs had over CFR Part 61 training.

However, Snody (2012) highlighted that many pilots pursue the easiest, fastest, and cheapest route to obtain a private pilot certificate and lack a solid foundation in flight training standards and standardization needed for professional pilot training beyond private pilot. Furthermore, Acur et al. (2015) examined the training environments associated with the most common flight training pathways: private, university, and military. Acur et al. noted that each pathway had inherent and unique flight training standards and standardization culture that influenced pilot future behavior.

Training requirements outlined in CFR Part 61 and CFR Part 141 differed significantly (e-CFR 61, n.d.; e-CFR 141, n.d.). As such, students who participated in a CFR Part 61 program have a fundamentally different training experience than if those who participated in a CFR Part 141 training program. However, the pilot knowledge and practical standards established by the FAA, as defined in the applicable PTS or ACS, require that each pilot demonstrate the same or similar standards and requirements to earn a commercial certificate or an instrument rating, regardless of the type training they may have received (FAA, 2011; FAA, 2013; FAA, 2018; Knecht & Smith, 2012; Pittorie, 2018; Sezen et al., 2015).

Therefore, it appeared to be widely accepted that CFR Part 61 and CFR Part 141 training programs, and by proxy non-collegiate and collegiate programs, respectively, are significantly different, yet completion standards between each type training program remained relatively the same between training environments. Prior work has assessed the safety, financial, and time differences between CFR Part 61 and CFR Part 141 training programs. However, there appears to be a dearth of existing literature that has examined the quality of CFR Part 61-trained pilot performance through a subsequent standardized commercial or instrument pilot training program, such as that found in a CFR Part 141 program.

Definition of Terms

Academic achievement was defined as the letter grade (A through F) assigned and deemed appropriate by the course professor that reflects the overall academic and practical performance of the individual in the prescribed course of instruction.

CFR Part 61 training was defined as any flight training conducted in accordance with CFR Part 61.

CFR Part 141 program was defined as any flight training conducted by a flight training organization that has developed and obtained approval from the FAA using a previously approved TCO.

Flight Time was defined in accordance with the University's FAA approved TCOs as including both flight training device (a.k.a. FTD or simulator) time and actual aircraft time.

Fractional / Hybrid / Partial Technologically Advanced Aircraft was defined as an aircraft equipped with any combination of analog (i.e., traditional six-pack, Very High Frequency Omnidirectional Range) and digital (i.e., Garmin G5, Garmin GNS 430/530) flight and avionics instrumentation.

Ground Instruction Time was defined as the amount of TCO required ground instruction time provided by a CFI.

Pilot performance was defined as successful completion of each line item within the Commercial Pilot and Instrument Pilot TCOs. For purposes of this study, pilot performance was measured through subjective observation of the student's activities by a CFI according to the performance measures specified in each TCO task and recorded in the student's flight training record as a RPL 1 through 5. Required proficiency level 1 (RPL-1) represented the student demonstrated only an introductory level of knowledge or skill. Required proficiency level 2 (RPL-2) represented the student had previously been introduced to the knowledge or skill area but made major / numerous errors or required a significant amount of instruction / coaching when demonstrating the knowledge or executing the skill. Required proficiency level 3 (RPL-3) represented the student was able to plan and execute the task safely with only minor coaching, instruction, and / or assistance to correct minor deviations / errors from TCO required training standards as identified by the flight instructor. An RPL-3 grade indicated that safe completion of the task was never in doubt. Required proficiency level 4 (RPL-4) represented the student was able to perform the activity without any instructor assistance to TCO required training standards. The student was able to identify and correct errors and deviations in an expeditious manner. The successful completion of the activity was never in doubt and the student demonstrated a satisfactory level of traditional piloting and systems operations skills. Required proficiency level 5 (RPL-5) represented the student was able to perform the activity with no noticeable deviation from their targeted values. Thus, lower RPL scores indicate poorer performance when compared to other RPL scores within the same course.

Residential Collegiate Flight Training Program was defined as any flight training program within a two- or four-year aviation or aeronautics degree completion plan offered residentially to collegiate students by an institution of higher education accredited by an accrediting agency recognized by the U.S. Department of Education (i.e., Southern Association of Colleges and Schools, Commission on Colleges).

Technologically Advanced Aircraft (TAA) was defined as an aircraft that utilizes advanced Global Positioning System (GPS) navigation as an essential element of the aircraft's primary avionics system. Every training aircraft owned and operated by the flight school studied was considered a TAA aircraft with an integrated G1000 avionics suite and an integrated Garmin GFC700 autopilot system.

Time spent was defined as the number of instructor contact hours required by the student to successfully satisfy the predetermined completion standards associated with each TCO lesson, as determined by the student's CFI and recorded in the flight training records. For purposes of this study, every lesson completed by the student in each course is included in the measurement to include repeated lessons and additional lessons needed by the student to satisfy the predetermined completion standards. This included two measures: ground and flight time.

Research Questions and Hypotheses

There were two overarching questions of this study, broken down into several sub-questions.

1. What was the difference in pilot performance during commercial and instrument flight courses between students who obtained a private pilot certificate from a residential collegiate program and students who obtained a private pilot certificate from a non-collegiate program?

a) What was the difference in pilot performance during the first third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

b) What was the difference in pilot performance during instrument flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

c) What was the difference in pilot performance during the second third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

d) What was the difference in pilot performance during the final third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

2. What was the difference in time spent (i.e., ground and flight time) in commercial and instrument flight courses between students who obtained a private pilot certificate from a residential collegiate program compared to students who obtained a private pilot certificate from a non-collegiate program?

a) What was the difference in time spent during the first third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

b) What was the difference in time spent during instrument flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

c) What was the difference in time spent during the second third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

d) What was the difference in time spent during the final third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program?

The corresponding research hypotheses were:

Q_{1a} / H_{1a}: $\mu_1 < \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate a lower level (smaller RPL mean) of flight training performance in the first third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{1b} / H_{1b}: $\mu_1 < \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate a lower level (smaller RPL mean) of flight training performance in instrument pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{1c} / H_{1c}: $\mu_1 = \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate the same level of flight training performance in the second third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{1d} / H_{1d}: $\mu_1 = \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate the same level of flight training performance in the final third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{2a} / H_{2a}: $\mu_1 > \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will require more time to complete the first third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{2b} / H_{2b}: $\mu_1 > \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will require more time to complete residential collegiate instrument pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{2c} / H_{2c}: $\mu_1 = \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will require the same amount of time to complete the second third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Q_{1d} / H_{1d}: $\mu_1 = \mu_2$: Students who obtained a private pilot certificate from a non-collegiate program will require the same amount of time to complete the final third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Study Design

Based on the previously proposed research questions, the most appropriate research methodology and design for this study was a quantitative, ex post facto, effects-type design. The target population for the proposed study was all collegiate aviation flight students. The accessible population for the proposed study was all residential flight students enrolled in the Mid-Atlantic region collegiate bachelor's degree program at the host university. The sample group for the proposed study included all the commercial and instrument flight students between 24 August 2015 and 21 August 2020 at the flight school being studied. The estimated sample size was expected to be approximately 400 records.

Data for the proposed study was collected utilizing a census of existing student data, progress reports, and records contained in the flight school's administration flight management system and academic records. The flight training record keeping system previously used by the flight school during the study period was MFT. For purposes of the proposed study, data was extracted from the archived database that was pertinent only to the commercial pilot TCO and instrument pilot TCO between the dates of 24 August 2015 (first day of the fall 2015 semester) and 21 August 2020 (last day of the summer 2020 semester). The database that was used for the proposed study contained the flight records of flight students who participated in the flight school's CFR Part 141 Private Pilot training. Although the details of each private pilot training record contained within the database were not retrieved or analyzed, the records of the students who had completed private pilot training at the host university were identified in the data collection process. Prior to deidentification of the dataset, each student record was categorized by Independent Variable (IV) group membership and assigned a reference number to satisfy record independence and improve internal validity.

Each flight course included not only TCO requirements that supported the development of practical flight skills, but also included academic requirements that facilitated cognitive development of flight students. Findings, as they relate to each flight course and the IV group membership, are provided in Chapter 4 of this study.

The university's flight records database did not include any information detailing or specifying the type of flight training received by an individual prior to arrival at the school being studied. Specifically, as it related to the current study, the database did not include any information that identified the type (residential collegiate or non-collegiate) of training received. However, what was determined was whether a student completed the host university's CFR Part 141 Private Pilot TCO. As such, those students who completed the flight school's CFR Part 141 Private Pilot TCO were automatically placed in the residential collegiate group.

Significance of the Study

This study provides a dataset that informs a greater understanding of student pilot training outcomes related to residential collegiate and non-collegiate private pilot training. The dataset enables a detailed review and comparison of training effects associated with residential collegiate training programs and non-collegiate training programs. The results of this study inform professional educators and future flight students of the costs and benefits associated with each type of flight instruction program. Additionally, this study informs the flight school's administration of the most effective and efficient means of developing a transition course of instruction for collegiate aeronautics students transitioning from a non-collegiate flight training model and structure to a more regimented and regulated residential collegiate flight training environment. Results from this study also help to inform the flight school's administration of focus areas for emphasis and instruction when developing a transition course from traditional analog flight instrumented aircraft flight training to flight training conducted in a TAA. Furthermore, results from this study inform the flight school's administration on transition program options that may facilitate student development and improve student success at the lowest possible cost to the student while maintaining a successful business model for the flight school. Findings from this study provide valuable insight on the effects and benefits of early, less-structured, less-regulated flight training in traditional analog equipped aircraft prior to instrument and commercial focused training in more advanced systems and aircraft. Differences in student performance observed, may inform further re research in the area of individual pilot ADM which may be informed by the results of this study, based on the type of private pilot training an individual received.

Finally, the findings of the proposed study may provide substantive and significant program information to other residential collegiate aeronautics programs who routinely accept non-collegiate trained Private Pilots into their flight training program. Due to the widespread standard practice within the collegiate aviation community of accepting previously held FAA certifications or ratings, findings from the proposed study will be widely applicable and perhaps impactful across collegiate aeronautics programs in the United States. Additionally, findings from the proposed study may be generalizable to other areas of collegiate education where students receive college credit for prior experience or certifications in lieu of a more formal, structured education. Findings from the proposed study may have implications on the value, or lack thereof, of structured focused training programs as compared to less regulated or structured training programs.

Study Limitations and Delimitations

Limitations

Limitations of this study included instructor grading variations, aircraft maintenance, weather impacts to flight operations, student financial issues, CFI-student interpersonal interactions, and restrictions inherent to the ex post facto design. Concerns related to potential instructor grading variations have already been discussed and mitigated through the collegiate program hiring and CFR Part 141 initial and recurring certification process. Students were scheduled for a minimum of two or three training activities per week to take advantage of the learning laws of exercise and recency (FAA Aviation Instructor's Handbook, 2008). In some instances, due to unpredictable weather or maintenance occurrences, the minimum number of flight activities was not achieved within the planned weekly activities and may have detracted from an optimum and consistent training cycle. As a part of the flight course registration process, students were required to provide funds to cover the associated lab fee adjusted to cover all flight related expenses based on historical data covering the average cost of 90% of previous graduates. Thus, so long as the student progressed through each flight course within the 90^{th} percentile, all flight related activities were covered by the pre-programmed and provided funds. When students expended their available funds and the remaining balance in the student's flight lab account approached either the $600 threshold for C-172 related training activities or $1,000 threshold for PA-44 related training activities, the student was counselled that additional funds were required to be deposited prior to continuing in training. In some instances, if the student did not have funds available in either their university student account or in a personal account, an interruption in training may have occurred until the student was able to secure additional funding. Very rarely did a student and CFI interpersonal relationship conflict develop that hindered effective training. As a part of the initial CFI collegiate program and CFR Part 141 instructor training protocol, instructors were educated on student and CFI relationship dynamics and how to adjust and adapt instructional methods and techniques to accommodate most student learning behaviors. However, in some instances, student and CFI interpersonal dynamics were not easily managed by the assigned CFI and Chief Instructor involvement was required. When deemed necessary by the Chief Instructor for continued student success, a student reassignment was completed.

To safeguard the confidentiality of subjects and remain fully compliant with IRB policies and approvals, for purposes of the current study, the researcher was provided with a deidentified dataset and restricted from directly accessing the database.

Inherent ex post facto design research limitations include the inability of the researcher to provide random assignment or manipulation of the IV, and the researcher does not have control over data collection or the quality of the data. In the current study, these limitations were outweighed and balanced by the census of all student records, readily available data, detailed CFR Part 141 record keeping, comprehensive data cleaning, and rigorous validity checking.

Delimitations

To facilitate more timely results and potential findings associated with the purpose of this study, an ex post facto, effects-based research methodology and design was selected for this study. Timeliness of study results and potential findings was accelerated with the use of archived flight training data spanning an approximate five-year period. However, inherent with ex post facto methodology research is a heavy reliance on data previously collected that may or may not have been collected in controlled environment by trained individuals. In the current study, the data was collected in an FAA regulated flight school environment as described in Chapter 3 by FAA CFR Part 141 CFIs. This study was delimited to the archived flight student records of one Mid-Atlantic region collegiate bachelor's degree program spanning a 5-year period between 2015 and 2020. In order to protect the rights and welfare of the individuals whose personally identifiable flight training records were stored in the archived database, the primary researcher was denied direct access to the database by the host university's IRB for purposes of this study. The host university provided a database SME facilitate collection of a deidentified dataset. Additionally, the host university assigned a flight training SME to assist in the subsequent data validation and cleaning process. Because an ex post facto methodology was used, group membership of the IV was already established and could not be manipulated. The DVs were selected based on the availability of detailed flight record data from a large group of collegiate flight students. Within the available flight record database, the selected dataset used was delimited to the data related to the flight courses that supported the FAA approved TCOs that guided commercial and instrument pilot flight training and certification at the host university. Flight data records for other courses offered by the host university, were not included in this study.

Chapter 2

Review of Related Literature

Introduction

This chapter reviewed available literature related to performance differences in student pilots based on CFR Part 61 or Part 141 private pilot training and by proxy the differences in private pilot training between non-collegiate and residential collegiate private pilot training. The chapter is organized in two main sections. The first section reviewed several previous studies related to CFR Part 61 and Part 141 training programs. Examination of prior work included aviation industry training results as well as non-aviation student performance outcomes. The review focused on three key aspects of aviation training: a) identification and understanding student motivational factors and influences as they applied to flight training, b) the effects and impact instructor quality and characteristics had on student learning and performance, and c) similarities and differences between CFR Part 61 flight training and CFR Part 141, by proxy non-collegiate and residential collegiate flight training. Educational learning behavior literature, as it applied to principles of human learning and performance outcomes was also examined. This section focused on improving understanding and correlating findings and conclusions discussed in previous aviation related literature with principles of human learning and performance identified in the education related literature.

Review of Previous Research

Safety, Financial, Time

Knecht and Smith (2012) conducted a study that compared a group of 1,838 GA pilot records, who were involved in a serious-to-fatal accident between 2003 and 2007, to a matched group of 63,951 non-accident GA pilot records. Pilot flight experience and flight risk exposure were operationalized based on whether a pilot held an instrument rating or not. Total pilot hours were accounted for as a statistical risk covariate capable of predicting total flight hour accident frequency. Knecht and Smith (2012) reported no substantial difference in GA accident rates between pilots who obtained their private pilot certificate through a CFR Part 61 program and pilots who obtained their private pilot certificate through a CFR Part 141 program. Thus, at the time of the study, there was not a substantial difference in accident rates for private pilots trained under Part 61 and Part 141.

When considering the number of hours required to complete flight training, Arch (2007) indicated that many prospective flight students are drawn toward CFR Part 141 flight programs because of the advertised fewer required hours associated with most CFR Part 141 TCOs. As a general statement, the number of training hours required under CFR Part 141 was less than the number of hours required under CFR Part 61. However, Arch (2007) noted that each TCO was individually written and approved for each flight school and varied in content, with the fundamental core training guidelines for each TCO mandated by the FAA. Arch

(2007) also reported that the average flight student required an additional 18% more hours than the minimum required by the applicable TCO. Of note, even when considering Arch's findings that additional hours were needed to complete the commercial single-engine, instrument pilot CFR Part 141 TCO program, the total number of hours needed to complete the CFR Part 141 program remained less than the minimum number of hours prescribed under CFR Part 61. Specifically, the minimum number of TCO training hours needed to obtain a single-engine, instrument, commercial pilot certificate was 190 total hours. When adding the additional 18% time required as determined by Arch (2007), the actual average number of hours needed was 224.2 hours, which remained less than the required 250 minimum total hours as prescribed in CFR Part 61.

Furthermore, Snody (2012) highlighted an underlying concern of aviation professionals, that many pilots pursued the easiest, fastest, and cheapest route to obtain a private pilot certificate and may not have been adequately prepared for the rigors of professional pilot training. Snody indicated that flight training in the United States had deteriorated to the extent that it only really qualified the flight training student to fly for recreation purposes. This would not normally be a problem except that with the projected professional pilot shortage, many student pilots envisioned that they would eventually fly professionally for either a corporation or airline, for which they had not been adequately trained or qualified within the degraded flight training environment found in the United States. Snody

(2012) acknowledged that no specific enrollment numbers had been maintained regarding the distribution of student pilots between CFR Part 61 flight training programs and CFR Part 141 programs. However, he did indicate that many students had gravitated toward the less structured and regulated CFR Part 61 training opportunities. That trend toward less structured CFR Part 61 flight training, away from FAA regulated and standardized flight training, further exacerbated the flight training deficiencies later observed by airline employers. Snody (2012) highlighted that although CFR Part 141 flight schools oftentimes employed and managed a younger instructor corps, CFR Part 141 flight schools typically had the necessary regulatory measures in place to provide a more standardized flight training environment. This further demonstrated the importance of flight training standards and standardization of flight training to develop a pattern of flight discipline and ensure flight safety.

Acur et al. (2015) provided additional insight as to why CFR Part 61 programs were more appropriate for recreational private pilot training, and CFR Part 141 programs were more appropriate for professional pilot training. Acur et al. reviewed common pathways for flight students to a pilot certificate. In doing so, they briefly highlighted the benefits and drawbacks of the three primary categories of pilot training: private, university, and military. Furthermore, Acur et al. noted that because CFR Part 61 schools were less regulated by the FAA than Part 141, they enjoyed a more relaxed training regimen and were much more flexible in rearranging flight lessons and content. Therefore, because the CFR Part 61 environment was a more relaxed and flexible training environment, it was far more appealing to a flight student who was pursuing a pilot certificate on a less regular, more dynamic schedule. On the other hand, Acur et al. noted that because CFR Part 141 schools were more closely regulated and received greater FAA oversight and interaction, they oftentimes required more rigorous training criteria of their students and offered flight students the opportunity to earn a pilot certificate in less time than CFR Part 61 instruction. Therefore, Acur et al. concluded that CFR Part 141 flight training was perhaps the better option for full-time flight students pursuing a career in aviation. Although the work completed by Acur et al. was valuable in understanding the motivational factors and training time associated with the various flight training pathways, their study failed to examine the resultant pilot performance associated with each type of flight training program.

Furthermore, Smith et al. (2010 and 2013) identified and subsequently verified that a structured and standardized approach to flight training produced a higher quality, more capable commercial pilot. In back-to-back studies, Smith et al. observed that in a sample of over 4,000 regional pilots, pilots with an aviation related bachelor's degree or collegiate based pilot training required fewer additional training events and had a higher initial operations qualification training completion rates than pilots who did not hold an aviation related degree or had not completed a collegiate flight program. It was also noted that even though airline qualification training records were meticulously maintained, there was no continuity or standardization between air carrier training programs. As such, although the findings provided further evidence that structured and standardized pilot training, such as that found in a CFR Part 141 program, produced a higher quality professional pilot, it did not identify pilot knowledge or performance deficiency areas that may be attributed to the type of training the pilot had previously received.

CFR Part 61 and Part 141 describe prerequisites and requirements that pilots were required to meet and satisfy in order to exercise the privileges associated with the applicable certification or rating (e-CFR 61, n.d.; e-CFR 141, n.d.). Although the CFR Part 61 and Part 141 training prerequisites and requirements vary between each part of the CFR for the same certificate or rating, the PTS or ACS that each pilot was required to demonstrate did not vary between parts of the CFR. Specifically, the PTS or ACS for each certificate or rating were identical regardless of the method or program of instruction (Acur et al., 2015; FAA, 2011; FAA, 2013; FAA, 2018; Pittorie, 2018; Knecht & Smith, 2012). Although the idea that having the same PTS or ACS is reasonable based on the life-threatening consequences of substandard pilot performance while operating an aircraft (e.g., failing to operate an aircraft in a safe manner), an expectation that standardized student outcome behavior from a non-standardized training program, based on a different set of prerequisites and requirements, should be questioned and validated.

Motivational Factors

Universal human limitations; bounded rationality and self-control. Options and choices are normally considered beneficial and good, especially when they facilitate and serve preference diversity. However, when bounded rationality and bounded self-control were considered within universal human limitations, more options and choices were not always better. When there were too many options or choices without bounded structure, an individual may have become overwhelmed and frustrated by the multitude of clear choices and options that achieved their goals. Individuals may have also become cognitively overloaded or confused by the multitude of options and may have selected an acceptable, but less than optimum option (Scott-Clayton, 2011). To further compound a sense of potential frustration, because of too many options and choices, a phenomenon referred to as regret aversion may have been experienced. Regret aversion may have occurred when an individual experienced difficulty in following through with a previous decision that could have been perceived as having limited other options and choices that would have resulted in a more effective or efficient plan (Scott-Clayton, 2011). This regret aversion, or the sense of being overwhelmed with choices and options, could have easily led to frustration and decision paralysis that stagnated and stifled a person's motivation, drive for success, and sense of purpose.

Scott-Clayton (2011) suggested that the lack of structure in many community colleges fostered inaccurate and inefficient educational path decisions.

To counter the lack of structure, some institutions or individuals may have overzealously pursued structure that resulted in a perception that added structure reduced choice, flexibility, adaptivity (Scott-Clayton, 2011). Many college students arrived knowing that they wanted to attend college and earn a degree, but many did not know what to do, how to plan an educational path, or how to achieve their goal of earning a degree. This same scenario could easily have been translated into a flight student's experience. Flight students knew that they wanted to pursue a profession in aviation, but they did not know what to do, how to plan a flight path, and how to achieve the goal of earning the necessary flight certificates and ratings needed as a professional aviator. In both scenarios, the students had very little practice functioning in a choice rich environment after having, in many instances, just graduated from high school and for the first time in their life, not be under the daily supervision of a parent or guardian. That newfound freedom, along with a multitude of other options, may have been highly prized and sought after by the student, but without appropriate guidance and structure, may have become overwhelming and confusing. As a result, many students were prone to decision paralysis as a result of the plethora of choices which may have also led to frustration and inefficient choices (Scott-Clayton, 2011).

Although Scott-Clayton's work focused on a non-aviation related environment, her work informed the current study through the lens of collegiate education. The issues Scott-Clayton (2011) reviewed in her work and her description of student responses provided valuable insight to similar training issues experienced in CFR Part 61 and non-collegiate flight training. Her review of student success and failure in the minimally structured community college system directly informed many issues observed in CFR Part 61 and non-collegiate flight training programs and illustrated the need for the added structure and standardization that has been routinely found in a CFR Part 141 programs and may help residential collegiate students navigate the convoluted flight training maze.

Standardization verses Innovation. In the past, effective aviation safety programs have heavily relied upon the standardization of operations and procedures. In the fast paced, everchanging, collegiate flight training environment, it was easy to understand the importance of a coherent and consistent standardization program that helped prevent the flight program from degenerating into chaos (Wetmore et al., 2008). As such, standardization was considered an advantageous and necessary element that formed the cornerstone of every flight school program. Additionally, because the focus of collegiate flight training programs was to develop and educate professional pilots, an essential element in the foundation of many collegiate flight education and training programs was development of standardization practices and programs similar to the practices and programs collegiate flight students would eventually encounter in their future professional setting. As with any endeavor and activity, a balanced approach typically provided the best results; this was true also in collegiate flight training.

Wetmore, et al. (2008) sought to better understand the balance between standardization and innovation in a professional flight school. Their research may also have been loosely used to describe and illustrate a generalized difference between a standardized, highly structured, regulated CFR Part 141 program and a more innovative, loosely structured, somewhat less regulated CFR Part 61 program. Wetmore, et al. conducted a mixed methods study of a CFR Part 141 certified collegiate aviation program using both National Transportation Safety Board (NTSB) data and a human subject questionnaire. The study focused on concerns related to aviation safety, Crew Resource Management (CRM), ADM, and flight training issues. The study surveyed a volunteer group of 33 college seniors who were near completion of their professional pilot degree program (Wetmore et al., 2008). Wetmore, et al. found that 39.4% of the students had achieved the established program goal of completing a commercial pilot certificate prior to the end of their junior year. Slightly more than half (57.6%) of the students had obtained a commercial pilot certificate prior to the end of their senior year. Wetmore, et al., found that school policy offered collegiate course credit to any student who obtained a pilot certificate or rating somewhere other than the current school. This policy not only permitted but, in fact, encouraged prospective and current flight students to obtain certificates and / or ratings elsewhere as a method of circumventing the school's stagnated and ineffective flight training program. Wetmore, et al., found that over half (57.6%) of the students had earned at least one pilot certificate or rating at another location. Additionally, of the students who were successful in completing the school's goal of obtaining a commercial pilot certificate prior to the end of their junior year, 84.6% had done so by completing their flight training with another flight training program (Wetmore et al., 2008). Wetmore, et al., further identified a lack of efficiency prevalent in the collegiate program that stifled and restricted normal student progression. Wetmore, et al., found that students were over-flying the program's CFR Part 141 minimum hours by an average of 108.8 additional hours (Wetmore et al., 2008). Thus, when other flight students were deciding on whether to pursue flight training under CFR Part 61 or Part 141, and when they learned of outlier examples of stagnated, inefficient CFR Part 141 flight programs (e.g., such as the program reviewed in the Wetmore et al. study), the appeal of a less structured, more flexible, and perhaps less expensive CFR Part 61 flight program became more attractive.

Wetmore, et al. (2008) identified and described a common perception regarding CFR Part 141 flight training programs: CFR Part 141 programs were too structured and inflexible. This common perception of collegiate programs operating under CFR Part 141 was further exacerbated by collegiate program policies that permit and encourage completion of certificates and ratings outside the collegiate program. An additional consideration when evaluating collegiate flight training programs that was not addressed in the Wetmore, et al. study is the coincident additional cost of the additional or extra average training time beyond the advertised course minimums. Future profession pilots and individuals (typically parents or guardians), who financially support them, were concerned with the financial burden associated with additional flight training and time. As such, students who considered training options to achieve their professional pilot certifications and education, were oftentimes confronted with the common perception that CFR Part 141 programs were too structured, too costly, and oftentimes required additional flight training beyond that required by the FAA minimums. As knowledge of the alternative flight training options was promulgated among students, more and more students sought the flight training path of perceived least resistance. Wetmore, et al. provided clarity into the background environment of collegiate aviation programs that informed the student flight training selection process between CFR Part 61 and CFR Part 141 flight training. Additionally, the Wetmore et al. study informed the current study by identifying and describing the friction between the pursuit of a less structured (CFR Part 61) flight training program and that of a more structured (CFR Part 141) flight training program with the need for innovation and balance to promote efficiency while safeguarding safety.

Instructor Quality and Characteristics

Instructor involvement and quality of instruction were foundational and influential in student motivation and success. Both inside aviation education circles and in mainstream education practice, the instructor and the instructor's approach were key to facilitating improved student engagement and performance. For more than 30 years, educational research has sought to better understand why there is such a low percentage of students who complete an undergraduate degree at their first college compared to students who either transfer to another college or never complete an undergraduate degree. This alarmingly poor rate of academic retention in higher education that has seen as many as one-fourth of all four-year collegiate freshmen not return to start their sophomore year and has been commonly referred to as the departure puzzle (Bjerke & Healy, 2010, p. 25). To better understand the relationship between learning environment effects and student retention, studies have focused on an instructor's role in promoting and developing an academically integrated environment for student retention and success. Academic integration involved an instructor developing academic activities or classroom-based experiences that shaped a student's perception of their degree. Instructors who promoted active learning in their students and other classroom activities that reinforced learning behavior, facilitated academic integration. Academic integration has been best observed and assessed through understanding student perception of their academic and intellectual development and achievement (Braxton et al., 2000, p. 571). Therefore, an instructor's approach directly facilitated student engagement, motivation, retention, and success. As such, if a flight instructor's approach to student engagement lacked motivation, professionalism, and purpose, his / her flight students would similarly struggle with developing sufficient motivation, professionalism, and purpose in their flight training.

Within the current study, the CFIs were hand selected and hired from a highly competitive flight instructor development program. Selection and hiring standards focused on an individual's motivation, professionalism, and purpose driven life. As such, the CFI corps who participated in providing the data used for the current study may be unique in their qualifications and attributes. In comparison, non-CFR Part 141 CFIs may have included the full-range of instructors, from those who were simply building time in pursuit of their long-term airline career goal to life-long, professional, seasoned CFIs, who held a passion for instruction. Under Part 61, CFIs were initially trained and evaluated by the FAA under CFR Part 61. Once certified, non-CFR Part 141 CFIs maintained flight instructor currency through biennial completion of a Flight Instructor Refresher Course (FIRC). There were no regulatory proficiency requirements established for non-CFR Part 141 CFIs. On the other hand, CFR Part 141 CFIs were similarly initially trained and evaluated by the FAA under CFR Part 61. However, once certified, CFR Part 141 CFIs received additional training and certification from a FAA designated Chief Instructor Pilot in the applicable FAA approved TCO(s) that CFI would provide instruction under CFR Part 141. Once initially certified by the Chief Instructor, the CFR Part 141 CFI would then be required to annually demonstrate sufficient knowledge and practical proficiency, by means of an oral and practical CFR Part 141 evaluation administered by the Chief Instructor Pilot or their representative, for each TCO that CFI was certified to provide instruction in. As such, the qualifications, currency, proficiency, standards, and scrutiny CFR Part 141 CFIs endured was substantially more involved than that for non-CFR Part 141 CFIs.

With a focus on better understanding the effect that a CFI has had on flight student success, Polstra (2013) found a measurable effect on student flight training completion times in his study at a major collegiate CFR Part 141 program. Polstra (2013) examined the relationship between a CFI's experience characteristics and training efficiency through measurement of student completion times in a CFR Part 141 collegiate program. Polstra (2013) defined CFI experience characteristics as the total number of flight instruction hours provided, number of months employed as a CFI, employment status (either full time or part time), instructor level, and total fight hours as a pilot. Student completion times included simulator and flight time. Within this environment and definitions, Polstra derived six questions with a corresponding null hypotheses and alternative hypothesis for each question:

> 1. To what extent does there exist a significant difference in effectiveness, as measured by student completion times in part-141 collegiate flight training programs, between instructors who have provided more hours of flight instruction and those who have provided less flight instruction?
>
> 2. To what extent does there exist a significant difference in effectiveness, as measured by student completion times in part-141 collegiate flight training programs, between flight instructors who have more months of job tenure and those who have less job tenure?

3. To what extent does there exist a significant difference in effectiveness, as measured by student completion times in part-141 collegiate flight training programs, between full-time instructors and adjunct instructors?

4. To what extent does there exist a significant difference in effectiveness, as measured by student completion times in part-141 collegiate flight training programs, between higher ranking flight instructors and lower ranking flight instructors?

5. To what extent does there exist a significant difference in effectiveness, as measured by student completion times in part-141 collegiate flight training programs, between flight instructors who have more hours of total flight time and those with fewer hours of total flight time?

6. To what extent does there exist a dominant instructor characteristic for predicting effectiveness, as measured by student completion times in part-141 collegiate flight training programs? (Polstra, 2013, p. 14)

Polstra (2013) completed a quantitative analysis of archival data using a series of simple regressions and multivariate regression based on student completion times. Normalization of student completion times was completed between each course examined. Seven years of flight records, between the years 2005 and 2011, were accessed consisting of 1,031 students and 100 flight instructors. Subsequent to a review of the data, the data set consisted of 381 distinct students and 100 CFIs.

Polstra (2013) reported that of the 85 private pilot students, the average completion time was 66.05 hours, with 57.11 hours of that time as dual instruction. Of the 108 instrument pilot students, the average completion time was 97.31 hours with 78.36 hours of dual instruction time. Of the 121 commercial pilot students, the average completion time was 118.64 hours with 62.19 hours of dual instruction provided. Of the 117 multi-engine students, the average completion time was 35. 32 hours, with 34.02 hours of dual instruction.

Polstra's (2013) study demonstrated a statistically significant relationship existed between a CFI's dual instruction given time and student completion times in the commercial and multi-engine programs. No such relationship existed in the instrument flight course. However, Polstra (2013) stated that student instrument rating dual instruction was most affected by the instructors' total flight hours and the average months of tenure as a CFI. Furthermore, Polstra (2013) concluded that no determination could be made regarding private pilot training due to insufficient sample size required to achieve sufficient power to support the findings. These results indicated that a CFI's experience had a measurable effect on student completion time with students receiving dual instruction from a more experienced CFI having fewer hours required for course completion. Additionally, there was an inverse relationship between a CFI's duration of employment and instrument students' completion times. Furthermore, a statistically significant inverse relationship was observed between a CFI's total flight time and the completion time of students in the three flight courses. A CFI's total flight time also provided the best indicator of teaching effectiveness as the primary factor affecting student performance in instrument and multi-engine training and the tertiary factor affecting student performance in commercial pilot training.

Polstra (2013) informed the current study by validating the effect an instructor has had on student completion times and accelerating student advancement. However, Polstra's (2013) work focused on CFI experience in a CFR Part 141 program and did not analyze or assess any effect a CFI's experience may yield in a less structured and regulated training environment, such as that found in a CFR Part 61 program or a non-collegiate training environment.

Human Learning and Performance Outcomes

Technology and transferability. Prior research focused on advanced technology integrated into General aviation aircraft (GAA) to determine the effects of technology on flight training. The fascination on advanced technology had even caused longstanding commercial and flight instructor certification standards to change in recent years. Several years ago, the FAA determined the integration of technology into the GAA satisfied and substituted the long-standing complex aircraft requirement for commercial pilots and CFIs completing their initial instructor certification (Wright & O'Hare, 2014).

With the rapid onset and propagation of advanced technology flight instrumentation and augmentation in GAA, the safety and effectiveness of TAA in GAA-based pilot training have been scrutinized. Wright and O'Hare found that,

> Previous training made little difference except in the accuracy of flying the heading in the third (descent) stage of the flight where prior training on the conventional cockpit displays negated the negative performance effect of the glass display in the test flight. (Wright & O'Hare, 2014, p. 298)

Although participants in the study indicated a clear subjective preference for the digital flight instrumentation over the analog instrumentation, the findings of the study indicated little difference in observed flight performance of the subjects (Wright & O'Hare, 2014). Wright and O'Hare provided valuable insight to an ongoing discussion regarding anecdotal evidence that suggested recent advancements and transition from traditional analog flight instrumentation displays to advanced digital flight instrumentation displays may have affected a pilot's initial performance and also produced potential negative transfer effects between flight instrumentation display systems (Wright & O'Hare, 2014). Wright and O'Hare used 62 non-pilot, first- and second-year Psychology students in their study. In an attempt to control the prior experience of the study group, Wright and O'Hare used subjects with no prior piloting experience, which limited the generalizability of their study's results to a student pilot population.

Wright and O'Hare expected to "find an interaction between display type used in training and that used in the criterion (test) flight on a range of dependent variables including flight performance, situational awareness and workload (Wright & O'Hare, 2014, p. 294). Wright and O'Hare analyzed several objective aspects of the simulator flight profile, including the number of crash incidents, primary flight performance focused on airspeed, heading, and altitude deviations from specified parameters. Additionally, subject-based questionnaires were administered to obtain subjective data related to subject-perception of situational awareness, workload, and display preference. Regarding incidence of crashes, a chi-square test of independence revealed a significant relationship between the type of flight instrumentation and the number of subjects who crashed ($\chi^2 = 5.455$, $df = 1$, $p = 0.02$), with participants more likely to crash using digital instrumentation than analog instrumentation (Wright & O'Hare, 2014, p. 296).

Subject flight performance was measured three dimensionally with deviations noted in altitude, heading, and airspeed assignments. For all three dimensions, the significant difference in variance from the assigned altitude, heading, or airspeed were transformed into Root Mean Square Errors (rMSE) for each subject. Those rMSE values were then used for statistical analysis using a two-way between-subjects analysis of variance (ANOVAs) for each phase (climb, cruise, and descent) of the flight profile. Wright and O'Hare found airspeed deviation values ranged from 2.38 to 42.24 ($M = 15.31$, $SD = 8.3$) in the climb phase, 2.92 to 53.39 ($M = 18.28$, $SD = 11.04$) in the cruise phase, and 5.18 to 36.84 ($M = 14.18$, $SD = 7.26$) in the descent phase (Wright & O'Hare, 2014, p. 296). Wright and O'Hare reported statistically significant findings in each phase of cruise flight and statistically significant findings in heading and altitude deviations measurements. They concluded that the flight performance of subjects using digital flight instruments was significantly worse than the subjects who used analog flight instruments. Additionally, Wright and O'Hare found that the previous controlled flight instrument training had little difference in the subject test performance except in one aspect of the evaluation, the accuracy of flying a heading during a descent, where it was determined that the analog training provided as a part of the study negated the general negative performance of subjects flying the test with digital flight instrumentation.

Several limitations to the Wright and O'Hare study included the time span of the study including a very short fundamentals of flight lesson and a single short duration observation of non-pilot subjects. The study was also limited in that the flight performance measurement took place in a simulator and not an actual aircraft. Generalizability of the study was limited due to the use of not aviation subjects in a simulator environment. Although the selection of test subjects with no prior piloting experience increased the validity of the study, the use of non-pilots diminished the generalizability to flight training environments. As such, the generalizability of the Wright and O'Hare study may inform similar analog verses digital studies in collegiate-aged subjects. Wright and O'Hare indicated that contrary to anecdotal evidence and demonstrated preference, transitioning from analog flight instruments to digital flight instruments did not negatively affect an individual's ability to safely operate an aircraft. Thus, the type of flight instruments used by students prior to beginning their Part 141 flight training was anticipated to have no significant effect on the student's subsequent performance.

Lindo, et al. (2012) conducted a comparison study on instrument rated pilots and their ability to transition between digital and analog instrumentation.

Lindo, et al. identified transfer of training as an effective and efficient means by which an individual learned or exercised a new skill in a different environment. They further emphasized the importance of individuals being able to transfer learned skills from a training environment to a work or operational environment. The effectiveness of transfer was measured by how well specific tasks were performed. When negative transfer of training in critical functions or operations from one environment to another occurred, such as an insufficient transfer of training between aircraft equipped with different avionics configurations, those situations may result in unsafe operations. Furthermore, with the rapid development of advanced technology in GAA where the layout of so-called glass cockpit displays did not accommodate a specific instrument scan as is found in traditional, analog equipped aircraft, pilots may have required additional fundamental instrument scan technique training when they transitioned from digital to analog instrumentation. On the other hand, pre-existing scan procedures exercised by analog-trained pilots may have made transition from analog to digital instrumentation easier (Lindo, et al., 2012).

FTDs were configured with avionics that did not match with the type of avionics the pilot had been instrument trained on. Specifically, analog trained pilots were studied while operating a digitally equipped FTD and digitally trained pilots were studied while operating an analog equipped FTD. Each category of pilot was voice prompted to fly the same profile and standard instrument maneuvers without regard for the type of avionics being used.

The study utilized 42 previously instrument-rated pilots from a local university. The sample was randomly selected from a group of volunteers with 21 of the individuals having been trained in glass cockpit aircraft and the other half of the participants having been trained in steam gauged aircraft. Of note, several of the participants' instrument flight experience included some flight time in both digital and analog equipped aircraft as noted by Lindo, et al. (2012). Criteria for profile and performance deviations was provided. Subjects were observed, and their performance was measured against the established criteria. The results of the multivariate analysis of variance (MANOVA) indicated a statistically significant difference on the combined dependent variables between digitally trained and analog-trained instrument pilots. Thus, Lindo, et al., accepted their alternative hypothesis that,

> The performance of pilots who obtained instrument training with glass cockpit display and transitioned to conventional display will be lower than the performance (as measured by airspeed, heading, altitude, localizer, and glideslope control) of those who received their instrument training with conventional display and transitioned to glass cockpit. (Lindo, et al., 2012, p. 67).

After further analysis, Lindo, et al., determined statistically significant differences existed for the airspeed, altitude, and glideslope; however, no statistically significant differences were found for the heading and localizer course

(Lindo, et al., 2012). They also determined that pilots who transitioned from analog gauged aircraft to digitally equipped aircraft had smaller deviations in airspeed, altitude, and glideslope parameters than pilots who transitioned from glass cockpits to steam gauge equipped aircraft; thus, steam gauge trained instrument pilots had an easier time transitioning to a glass cockpit than glass cockpit trained pilots had transitioning to steam gauged aircraft. Of note, there was no significant variance in statistical data that indicated any loss in transfer of training for heading or localizer course control. Therefore, transfer of training was more favorable when transitioning from an analog equipped aircraft to a digitally equipped aircraft as opposed to the transition from digital to analog instrumentation (Lindo, et al., 2012).

The Lindo, et al. (2012) research informed the current study by demonstrating that the transition from an analog equipped aircraft to a digitally equipped aircraft was easier and more favorable than the inverse. In the context of the current study, student transition from previous aircraft equipment to the proposed study's equipment would have be either a digital to digital, analog to digital, or fractional / hybrid / partial TAA to an all-digital transition.

Although the Lindo, et al. (2012) study recognized and examined the dramatic general aviation industry wide shift from traditional analog aircraft instrumentation toward modernized digital instrumentation the extent of that shift was better illustrated in the NTSB Safety Study on the Introduction of Glass

Cockpit Avionics into Light Aircraft (NTSB, 2010). In that study, the NTSB identified the rapid shift in new aircraft manufacturing preferences from aircraft manufactured with analog instrumentation to digital instrumentation in just a short 4-year period between 2002 and 2006. As described in the NTSB study, of the approximately 1,400 new aircraft registrations in 2002, nearly 100% of those registrations indicated the aircraft was configured with a traditional, analog style instrumentation. Four years later, in 2006, a complete shift in newly registered aircraft instrumentation configuration had occurred with nearly 100% of the 2,100 newly registered aircraft having modern, digital instrumentation (NTSB, 2010). Although the results of the NTSB study were mostly inconclusive regarding the accident rates in general aviation with the rapid introduction and transition of general aviation aircraft to glass cockpits, the study did provide informative data related to the speed and veracity of the general aviation transition to glass cockpit configurations (NTSB, 2010). The study also identified that an underlying purpose of the study was to better understand and perhaps validate the widespread perception that modern, digital instrumentation enhanced aviation safety due to the improved instrumentation reliability and presentation of additional / supplemental information to pilots that may have enhanced safer flight operations (NTSB, 2010). What was lacking in the NTSB study was any reference to or information related to number aircraft that with the rapid transition from traditional analog instrumentation to modern digital instrumentation had been modified by aircraft owners to incorporate a fractional / hybrid / partial digital instrumentation configuration. What the NTSB study did determine was the lack of adequate FAA regulations, guidance, and information regarding the use of digital flight instrumentation systems or components.

Similarly, even though there appears to have been ample commentary in publications related to the increased numbers of fractional / hybrid / partial digitally integrated instrumentation configurations into traditional analog equipped aircraft, there appears to be a lack of definitive research on the number of aircraft that have been modified to incorporate a mix of traditional analog and modern digital instrumentation (Evolution, 2018; Garmin, 2016; Koebbe, 2019; Mark, 2018; Pope, 2018). In response to this widespread public commentary and rapid growth in use of modern digital flight instruments in general aviation aircraft, the FAA developed a new Advanced Avionic Handbook with Chapter 2 written to address general features and functions associated with modern electronic flight instruments (FAA, 2009). Additionally, the FAA published Advisory Circular 25-11B that provided guidance and compliance requirements associated with "the design, installation, integration, and approval of electronic flight deck displays, components, and systems installed in transport category airplanes" (FAA, 2014, p. i).

Therefore, although there may be uncontrolled aircraft equipment variables associated with a student's previous flight training under CFR Part 61 or in a non-collegiate environment in the current study, those variables are less significant given Lindo et al.’s work, the apparent widespread use of fractional / hybrid / partial digital instrumentation in general aviation aircraft and the aircraft used in the proposed study were all digitally equipped.

Known Verses Unknown Prior Experience Training Transfer.

In a 2008 study conducted at the Southern Illinois University (SIU) at Carbondale, Robertson and Harrison compared the success rate and required completion time between several categories of flight students. Robertson and Harrison sought to better understand and quantify the anecdotal evidence that was widely and informally accepted throughout collegiate flight training programs that flight training pilot performance subsequent to private pilot training was different between pilots who trained for a private pilot certificate under CFR Part 61 and those pilots who trained under CFR Part 141. They sought to identify pass rate and time required differences between students who participated in the instrument and commercial multi-engine flight program in the fall 1998 to summer 2003 time period, using an ex post facto descriptive study of 338 collegiate flight students. Robertson and Harrison sought to answer six questions:

> 1. Is there a difference in the successful completion of instrument flight training between students who earn their private pilot's license at the university and those who complete their private pilot training elsewhere?
>
> 2. Is there a difference in the successful completion of multi-engine training between students who earn their private pilot's license at the university and those who complete their private pilot training elsewhere?

> 3. Is there a difference in days-to-degree between students that complete their private pilot's license at the university and those who complete their private pilot training elsewhere?
>
> 4. Is there a difference in the successful completion of instrument flight training between transfer private pilots who enter directly into instrument training and those whom must take proficiency or evaluation training?
>
> 5. Is there a difference in the successful completion of multi-engine training between transfer private pilots who enter directly into instrument training and those whom must take proficiency or evaluation training?
>
> 6. Is there a difference in days-to-degree between transfer private pilots who enter directly into instrument training and those whom must take proficiency or evaluation training? (Robertson & Harrison, 2008, p. 79).

Robertson and Harrison summarized aspects and elements of FAA Part 61 and Part 141 training programs, but then stated that the type of prior flight training had less of an effect on student performance than the quality of ground and flight instruction provided by the flight instructor. Although Robertson and Harrison cited the *Airplane Flying Handbook* (FAA, 2016) in stating that training programs were dependent on the quality of ground and flight instruction, they failed to include the additional expectations and standards CFIs were required to attain and maintain when operating independently or outside the support structure provided by a CFR Part 141 program. Additionally, Robertson and Harrison seemingly glossed over the additional information provided in the same section of the *Airplane Flying Handbook* that compared characteristics and qualities between non-certified flight schools operating under CFR Part 61 to FAA-approved schools operating under CFR Part 141 (FAA, AFH, 2016, pp 1-7, 1-10). As such, Robertson and Harrison minimized the stringent personnel, equipment, maintenance, and facilities certification requirements a CFR Part 141 flight school was required to meet and provide in order to attain and maintain their FAA certification status. The *Airplane Flying Handbook* highlighted the rigorous and extensive FAA approved curriculum, enrollment prerequisites, lesson standards, lesson objectives, expected accomplishments and standards for each stage of CFR Part 141 flight school training (FAA, AFH, 2016 pp 1-8). The additional requirements associated with a flight school having received and subsequently operating under CFR Part 141 certification from the FAA provided a foundation that may have substantially contributed to improving the learning environment and enabled CFR Part 141 certified flight instructors to provide a higher level of quality instruction on average, when compared to training environments and programs that were less regulated. Therefore, although Robertson and Harrison correctly cited the *Airplane Flying Handbook* and the benefits of a CFR Part 141 flight school, they discounted the intrinsic value of ensuring a consistent, professional, safe training environment regulated and certified by the FAA under CFR Part 141 in favor of placing a greater value on the ability of a CFI to overcome or compensate for a less regulated non-certified flight training program and environment. The Aviation Instructor's Handbook (AIH) stated that "helping a student achieve his or her individual potential in aviation training offers the greatest challenge as well as reward to the instructor" (FAA – AIH, 2008, p. 1-4). Essential to this challenge was the instructor's ability to meet the student's basic human needs as described in the AIH (2008). The most basic of the student's needs are physiological (a.k.a. biological) and security (a.k.a. safety). Although it has been incumbent upon the instructor to meet each of those needs in their student's life with each lesson, those needs should have been managed at the level above the instructor in order to ensure that the instructor and student were both afforded a healthy and safe environment.

Robertson and Harrison (2008) provided insight into an ongoing challenge CFR Part 141 collegiate flight programs faced and described an attempted potential solution that was implemented by Southern Illinois University at Carbondale: the development of a Private Pilot Transition Course for arriving students who had already obtained a private pilot certificate from somewhere other than SIU. Robertson and Harrison provided a brief explanation of the process developed by SIU to resolve the same anecdotal evidence of nonstandard pilot performance observed between students who had obtained a private pilot certificate prior to arriving at SIU and those students who obtained a private pilot certificate as a part of SIU's CFR Part 141 collegiate flight program. Specifically, students that entered the SIU flight program after having obtained a private pilot certificate were required to begin their training with SIU in a Private Pilot Transition Course. The SIU Private Pilot Transition Course consisted of 10 to 14 hours of flight instruction and served as a private pilot refresher and evaluation course. Successful completion of the SIU Private Pilot Transition Course provided the student with academic credit for having already obtained a private pilot certificate and furthermore enabled that student to begin the SIU instrument training. Robertson and Harrison adopted the terms, native student and transfer students when identifying students who had completed private pilot training at SIU and students who had completed their private pilot training somewhere other than with SIU, respectively. Robertson and Harrison conducted the statistical analysis of the study population's archival data based on these group membership operational definitions. Additionally, Robertson and Harrison further defined the transfer student category by identifying transfer students who had, prior to beginning instrument training with SIU, completed some form of screening and / or completed a checkride with a Designated Pilot Examiner (DPE) familiar with the rigors of the SIU flight program. Students in that category were identified as proficiency transfer students, and students who had not completed any additional screening and / or completed a checkride with a SIU affiliated DPE were then identified as direct-entry transfer students. Although this additional categorization of transfer students was not specified within any of the research questions, Robertson and Harrison analyzed and provided their observation as a part of their conclusions and recommendations.

Of the 336 students, 202 were native and 134 were transfer students. Transfer students had an overall higher pass rate in the instrument pilot course with 94 of 134 (~70%) completion rate compared to native students with 136 of 202 (~67%) completion rate. In the multi-engine course, 72 of 134 (54%) transfer students completed the course compared to 97 of 202 (~49%) native students. When considering the number of days to complete the flight degree program, the mean number of days for transfer students was 829 days compared to 873 days for native students. Robertson and Harrison did note that the mean number of days for native students was skewed due to 6 outlier students who required six or more semesters to complete their degree. When accounting for these 6 outlier students, the mean number of days for native students dropped from 873 down to 838. Robertson and Harrison also provided findings related to differences between proficiency and direct entry transfer students. Roberson and Harrison found 78 direct entry transfer students and 56 proficiency transfer students. Of the 78 direct entry transfer students, ~74% completed instrument training and of the 56 proficiency transfer students, ~64% completed instrument training. Of the same 78 direct entry transfer students, ~57% completed multi-engine training and of the 56 proficiency transfer students, ~50% completed multi-engine training. Finally, direct entry transfer students completed their flight degree program in 831 days (mean) compared to proficiency transfer students who completed their flight degree program in 825 (mean) days. When assessing their findings, Robertson and Harrison concluded that for each of their six research questions, no statistically significant differences were noted in pass rate or days to course completion. Roberson and Harrison concluded that when comparing days of training, instrument training completion rates, and degree completion rates, there was no statistically significant differences between native and transfer private pilots. Furthermore, they concluded that within the transfer category of students, there was no statistical difference between students who completed the transition course and those students who were permitted direct entry into the flight program. Thus, a student pilot's transfer status was not a good indicator of a student pilot's future success. Robertson and Harrison further concluded that proficiency training or testing did not appear to be a good indicator of student flight training future success (Robertson & Harrison, 2008, pp 80-85).

In completing a review and critique of the Robertson and Harrison study, the intent of their study was to determine if there was quantifiable evidence of a statistically significant difference between students who began collegiate flight training having already obtained a private pilot certificate and students who began collegiate flight training without having already obtained a private pilot certificate. Robertson and Harrison sought quantitative evidence that would have validated the effectiveness of the SIU developed transition course and the transfer student policies implemented by SIU to mitigate an anecdotal perception that students who had obtained a private pilot certificate prior to beginning flight training at SIU did not perform as well as students who had obtained a private pilot certificate with SIU.

As such, the Robertson and Harrison study informed the current study in many regards. First, Robertson and Harrison undertook their study as a result of a) anecdotal evidence that students who had begun flight training elsewhere had some difficulty either performing or transitioning into a collegiate program and b) a lack of similar substantive research within the collegiate aviation community. Second, Robertson and Harrison conducted their study using archival data from a single major collegiate aeronautics program certified to provide flight instruction leading to private and commercial pilot certificates and an instrument pilot rating, with each collegiate program of instruction regulated under CFR Part 141, which provided credence to the current study's selected methodology for approaching similar questions. Third, Robertson and Harrison identified the IV group membership as transfer and native students, which corresponded to students who earned a private pilot certificate in a non-collegiate training environment either under CFR Part 61 or 141 and students who earned a private pilot certificate at SIU under CFR Part 141. Robertson and Harrison were limited in their ability to determine what type of flight training was completed prior to the student's flight training at SIU. They did not find a significant difference in training time to certification between native and transfer students, which indicated that their transition course may have brought transfer students up to existing SIU standards. However, the transfer students were categorized as either proficiency transfer students who gained proficiency by means of a previously established transition course, or they were categorized as direct-entry transfer students who were granted direct-entry after having previously completed their private pilot checkride with an

SIU faculty member serving as an FAA examiner. Additionally, Robertson and Harrison did not look at the training type (CFR Part 61 or 141), nor did they examine student performance.

Summary and Study Implications

As described in this chapter, there have already been studies to assess the safety, financial, and time differences in flight training, but prior to the current study there appeared to be an absence of any substantive comparative evaluation of the quality of non-collegiate-trained pilot performance through subsequent professional commercial or instrument pilot training (CFR Part 141) program. In the collegiate flight training community, it has been accepted anecdotally that CFR Part 61 and CFR Part 141 training programs and standards are significantly different. The apparent incongruency between training program standards has manifested itself anecdotally in subsequent flight training pilot performance.

While Robertson and Harrison (2008) considered pass rates and days to complete each flight training program in the aggregate, they found no differences. However, the program used in their study had already implemented a transition course to minimize transfer student training issues, and they did not examine performance or the type of prior flight training. Individual student pilot performance throughout a commercial and instrument flight training was examined to determine specific areas of variance between students previously trained within a non-collegiate program and a residential collegiate program. Additionally, time to complete the flight training courses was analyzed at a finer grain scale: the number of hours required to complete each commercial flight course stage of training was analyzed. In doing so, a better comparison of the time to complete each stage and course between non-collegiate trained private pilots and residential collegiate trained private pilots was achieved. As a result, the greater level of insight into the pilot performance differences between residential collegiate and non-collegiate trained pilots produced by this study, may enable residential collegiate programs to tailor transitions courses and lessons that may facilitate future smoother transition courses for students who may be transitioning from non-collegiate flight training to residential collegiate flight training programs.

Chapter 3

Methodology

Population and Sample

Population. The target population consisted of the records for all residential collegiate aviation flight students in the United States. The accessible population consisted of the records for flight students at a collegiate aeronautics program located in the Mid-Atlantic Region of the United States. Within the accessible population, participation in this study was limited records for residential collegiate students, who were registered in a Bachelor of Science in Aeronautics degree program and completed one or more of the required commercial pilot or instrument pilot flight courses associated with their respective degree completion plan. Degree major alone was not sufficient criteria for inclusion of the student record in the current study. Bachelor of Science in Aeronautics degree programs were identified as Bachelor of Science in Aeronautics: Commercial / Corporate, Bachelor of Science: Unmanned Aerial Systems, Bachelor of Science: Global Studies, and Bachelor of Science: Military. Bachelor of Science in Aeronautics degree programs included participation and completion in the following flight courses: AVIA 320 Instrument Flight, AVIA 325 Commercial Flight I, AVIA 326 Commercial Flight II, AVIA 327 Commercial Flight III.

According to the FAA Civil Airmen Statistics for the year 2019, the demographics of pilots in the United States in 2019 were 664,565 total pilots, 611,825 (~92%) male pilots, 52,740 (~8%) female pilots. Of these, 21,694 pilots were under the age of 20, 17,901 (~83% of this age category) were male pilots under the age of 20, and 3,793 (<17% of this age category) were female pilots under that age of 20. In the age range that matched the accessible population, there were 70,041 total pilots between the ages of 20 and 24: 60,817 (~87% of this age category) were male pilots, 9,224 (~13% of this age category) were female pilots. Above age 24, there were 572,830 (~86%) pilots: 533,107 (~93% of this age category) male and 39,723 (~7% of this age category) female.

Sample. The sample for the proposed study consisted of a census of flight student records from the accessible population (i.e., all records at the host university) during the five-year period 2015 to 2020. By conducting a census of the accessible population, a representative sample of the population was assured.

Power Analysis. A power analysis determined the minimum sample size required to correctly reject a null hypothesis at predetermined alpha and beta levels. When conducting a power analysis using the computer program G*Power 3.1.9.2, using the a priori, *F* test, MANOVA: Repeated measures, within-between interaction with $\alpha = .05$, power = .8, an estimated effect size of .3 (medium effect), with 2 groups (residential collegiate trained private pilots and non-collegiate trained private pilots), and 2 measurements (flight and ground time), the minimum total sample size required was 126 records.

The original sample size obtained in this study was 568 individual flight records. However, of those 568 records, there were 36 pairs of duplicate / redundant records that were evaluated with the assistance of a subject matter expert designated by the Dean of the school providing the data. After reviewing the records, with the advice of the subject matter expert, several records were merged and or excluded resulting in a final a sample size of 530 individual records. Further review of the dataset and the association of each record to each of the applicable flight courses resulted in 360 records associated with the Commercial Flight 1 course, 215 records associated with the Instrument Flight course, 284 records associated with the Commercial Flight 2 course, and 275 records with the Commercial Flight 3 course. To achieve sufficient power with the previously provided parameters, a total sample size of 122 is required to achieve a .8 power. As such, the provided data set provided sufficient power to support the desired probability of finding a true effect if one was present.

Instrumentation

Archival Data. This study was an ex post facto study of archival data collected from a collegiate aeronautics program located in the Mid-Atlantic Region of the United States. Data used in this study was extracted from the flight department's archived student flight records. Archived data was retrieved from the proprietary secure database maintained by the University's Information Technology Department. The flight management program used to manage, record, and populate the database during the study period was the licensed and FAA approved aviation management software program MFT, a product of My Flight Solutions. The study collected data from the records of all students who had completed flight training at the host university during the period between August 2015 and August 2020 (inclusive).

The use of archival data for this study permitted timely access to five-years' worth of collegiate aeronautics program's flight data for all commercial and instrument flight courses and provided a dataset large enough to achieve adequate study power. Within the accessible database, student flight records and performance records spanned a period as little as one collegiate semester (approximately a three-month observation period) per student to as much as five (or more if the student failed to progress in the course and had to repeat the course as second semester) collegiate semesters (approximately a fifteen-month observation period). Additionally, the database used for the proposed study included individual performance measurements on each line item of each training unit within each training course. Thus, use of the archived database provided a large dataset to observe an adequate number of records with numerous measurements in commercial and / or instrument flight training across an extended period of time. The dataset was collected over a five-year period from flight instructors who were trained and certified in accordance with CFR Part 141 to conduct ground, simulator, and flight training as outlined in TCOs approved by the FAA. All the data contained in the dataset was CFR Part 141 derived data and provided an established, standardized means of obtaining and recording student performance, thus reducing the potential of any instrumentation or experimenter effects.

Participant population demographics, including age and gender, were stripped from the dataset prior to review and analysis. The number of student flight records accessed was 843 records. After validation of the applicability of each flight record to the scope of this project, specifically only the records from students who had completed at least one semester in either the commercial or instrument course were considered applicable for this study, the final number of student flight records was 530 student flight records.

At the time of instruction, each flight course (AVIA 325, AVIA 320, AVIA 326, and AVIA 327) dataset used in the proposed study was approved by the FAA under Part 141 and executed by means of an FAA reviewed TCO. Within each TCO, each training unit (a.k.a. lesson) provided specific guidance and parameters that included elements such as the training media, planned lesson time, lesson prerequisites, knowledge objectives for ground lessons, simulator / flight training objectives / tasks with specific required proficiency levels, completions standards, and homework assignments for the subsequent lesson. Training media included associated training requirements, such as a flight briefing room, a flight simulator, and / or a training aircraft. Planned lesson time included time allotted for every aspect associated with the lesson, including preflight briefing time, aircraft /

simulator flight time, and postflight debriefing time. Lesson prerequisites included any administrative actions needed prior to the lesson (e.g., course enrollment by the chief instructor), completion of any ground, simulator, or flight lesson required by the TCO, and any associated previously assigned homework for the specific lesson. Knowledge objectives included descriptive levels of student performance required during the lesson. An example of the knowledge objectives is provided in Figure 3.1.

Figure 3.1

Knowledge Objectives Associated with Instrument Airplane TCO LUSOA, 14 CFR Part 141 Instrument Airplane Training Course Outline, Revision 1

BROAD INSTRUMENT RATING ACS KNOWLEDGE OBJECTIVES These are objectives common to most of the flight training units in this course. Students are expected to fully achieve these objectives by the end of the course.
Be able to demonstrate ACS knowledge of single-pilot resource management. (01019)
Be able to demonstrate ACS knowledge of aeromedical factors. (02018)
Be able to demonstrate ACS knowledge of runway incursion avoidance. (03014)
Be able to demonstrate ACS knowledge of visual scanning & collision avoidance. (04007)
Be able to demonstrate ACS knowledge of the principles of flight. (05019)
Be able to demonstrate ACS knowledge of weight and balance. (06047)
Be able to demonstrate ACS knowledge of navigation and flight planning. (07113)
Be able to demonstrate ACS knowledge of night operations. (08007)
Be able to demonstrate ACS knowledge of the national airspace system. (10151)
Be able to demonstrate ACS knowledge of nav systems and radar services. (11050)
Be able to demonstrate ACS knowledge of certificates and documents. (121216)
Be able to demonstrate ACS knowledge of weather information. (13016)
Be able to demonstrate ACS knowledge of weather reports and charts. (14078)
Be able to demonstrate ACS knowledge of performance and limitations. (15017)
Be able to demonstrate ACS knowledge of airworthiness requirements. (16044)
Be able to demonstrate ACS knowledge of radio comms and ATC light signals. (17065)
Be able to demonstrate ACS knowledge of airport operations. (18048)
Be able to demonstrate ACS knowledge of airframes. (19006)
Be able to demonstrate ACS knowledge of flight controls and trims. (20006)
Be able to demonstrate ACS knowledge of powerplants. (21088)
Be able to demonstrate ACS knowledge of landing gear systems. (22018)
Be able to demonstrate ACS knowledge of fuel systems. (23016)
Be able to demonstrate ACS knowledge of hydraulic & pneumatic power systems. (24017)
Be able to demonstrate ACS knowledge of electrical systems. (25020)
Be able to demonstrate ACS knowledge of aircraft inst. systems and electronics. (26049)
Be able to demonstrate ACS knowledge of fire protection systems. (27008)
Be able to demonstrate ACS knowledge of cabin environmental control systems. (28013)
Be able to demonstrate ACS knowledge of ice and rain protection systems. (29015)

Note. An example of Knowledge Objectives from the instrument TCO. (Instrument Airplane TCO LUSOA, 14 CFR Part 141 Instrument Airplane Training Course Outline, Revision 1, 28 August 2017, p. C-7-2)

Simulator / flight training objectives / tasks were specified in each lesson and included specific RPLs for each line item. Required proficiency levels were approved by the FAA and defined within each TCO utilized by the host university. Proficiency levels described in each TCO directly supported each TCO grading strategy and provided continuity and reliability in the instructor's evaluation of student performance. Each TCO unit consisted of a set number of training elements, referred to as 'line items'. Each line item was assigned a specific proficiency requirement. Proficiency levels were graded on a 5-point scale. RPL-1 represented the student demonstrated only an introductory level of knowledge or skill. An example of an RPL-1 grade would have been when the flight instructor demonstrated slow flight to the student for the first time. The student then attempted to fly the maneuver for the first time. This student was expected to have only an introductory level of skill at that unit. RPL-2 represented when the student had previously been introduced to the knowledge or skill area but made major/numerous errors or required a significant amount of instruction or coaching when executing the knowledge or skill. An example of an RPL-2 grade would have been when a student, in a previous lesson had been introduced to slow flight, but now, in the current lesson, the student made major errors when attempting to control airspeed and altitude while performing slow flight, such that instructor intervention was required. RPL-3 represented when the student was able to plan and execute the task safely with only minor coaching, instruction, and / or assistance to correct minor deviations / errors from TCO required training standards as identified by the flight instructor. An RPL-3 grade indicated that safe completion of the task was never in doubt. An example of an RPL-3 grade would have been when, the student demonstrated slow flight but made minor deviations beyond the TCO required training standards in maintaining the target altitude or airspeed. RPL-4 represented when the student was able to perform the activity without instructor assistance within TCO required training standards. The student was able to identify and correct errors and deviations in an expeditious manner. The successful completion of the activity was never in doubt and the student demonstrated a satisfactory level of traditional piloting and systems operations skills. An example of RPL-4 would be when the student performed the entire slow flight maneuver within TCO required parameters, at all times. RPL-5 represented when the student was able to perform the activity with no noticeable deviation from their targeted values. An example of RPL-5 would have been when the student performed the entire slow flight maneuver with no noticeable deviations throughout the entire maneuver. To ensure continuity and reliability in training and evaluation within each TCO, as a part of the hiring and indoctrination process, each flight instructor was initially trained and certified by the Chief Instructor Pilot (or his / her representative) on each maneuver and grading process to objectively evaluate student performance based on each TCO line item RPL. Additionally, each flight instructor was annually recertified by the Chief Instructor Pilot or his / her representative to provide instruction in accordance with the TCO requirements. An example of a lesson flight training objective table from the instrument TCO is provided in Figure 3.2.

Figure 3.2

Flight training Objectives and Tasks Associated with Instrument Airplane TCO, Lesson: Unit 6, Instrument Airplane TCO LUSOA, 14 CFR Part 141 Instrument Airplane Training Course Outline, Revision 1

Task #	Task Title	RPL
2.1.7	Instrument Takeoff	2
3.1.3	Enroute Climb	2
3.1.5	Vy Climb	2
3.2.3	Straight and Level Low-Speed Cruise Flight	2
3.2.4	Straight and Level High-Speed Cruise Flight	2
3.2.6	Normal Turn to a Heading	2
3.2.13	Climbing Turn to a Heading	2
3.2.14	Descending Turn to a Heading	2
7.4.2	Steep-Banked Turn in Both Directions	2
7.5.3	Recovery From Nose-High and Nose-Low Unusual Attitudes in Simulated IMC	2
3.4.13	Intercepting and Tracking of a VOR/Localizer Course	2
3.4.15	Intercepting and Tracking of an RNAV/GPS Course	2
3.3.5	Constant-Airspeed Approach Descent	2

Note. An example of a lesson flight training objective table from the instrument TCO. (Instrument Airplane TCO LUSOA, 14 CFR Part 141 Instrument Airplane Training Course Outline, Revision 1, 28 August 2017, p. C-7-15)

If the student was able to demonstrate the required level of proficiency for every item in the unit, and the completion standards were met, then the unit was graded as satisfactory. However, if the student was unable to meet the specified proficiency requirement for any single item in the training unit, then the entire training unit was graded as unsatisfactory. Homework assignments were included in each lesson and ranged from reading assignments that prepared the student for the subsequent lesson, to assignments as given by the instructor, based on the student performance or demonstrated weak areas of knowledge in the current lesson.

Frequency of training is an important element in flight training and attempts to take advantage of the Exercise Principle of Learning as described in the FAA's Aviation Instructor's Handbook (2020). As such, each student was scheduled with an assigned flight instructor for a minimum of two periods of instruction per week over the course of a semester. Approximately 50 percent of the students were scheduled with an assigned flight instructor three periods of instruction per week over the course of a semester. When a scheduling conflict occurred, or when for any other reason, a student and instructor were not able to be scheduled together a minimum of either two or three times a week, other attempts to complete a minimum of either two or three events per week were explored. For example, if weather conditions prevented safe or effective lesson execution, additional training opportunities were considered within the limits of the host university's assets and student and instructor availability. If aircraft availability due to maintenance readiness limited training opportunities, additional training opportunities were considered within the student and instructor availability when the aircraft maintenance availability was more favorable. Also, if a scheduling conflict or instructor illness affected an instructor's availability to meet with an assigned student during the regularly assigned weekly training period, a fill-in alternative flight instructor certified in the applicable TCO was assigned, when available.

Training Environment and Equipment. Each of the 20 available flight briefing rooms available for pre- and post-flight briefings and ground lessons were standardized and routinely provided a distraction free learning environment. The flight training devices used for simulator training approved within each TCO were inspected daily and certified as meeting training standards and requirements that supported each TCO, as specified and directed by the FAA. If a flight training device did not meet the standards or requirements for training use and certification, that training device was removed from student training scheduling until the applicable repairs could be completed and device recertified. All Flight Training Devices (FTDs) utilized by the host university program were FRASCA produced FTDs. Available FTDs included three FRASCA C-172 Level D FTDs, one FRASCA PA-44 Level D FTD, and seven FRASCA Reprogrammable Training Devices (RTDs). Each training device was equipped with a Garmin G1000 avionics suite designed to replicate as closely as possible the host university's fleet of aircraft. The aircraft owned and operated by the host university included 20 Cessna C-172 SP (Skyhawk) aircraft and 5 Piper PA-44 (Seminole) aircraft. Within each aircraft category (i.e., single-engine land and multi-engine land), aircraft configuration was standardized and included a Garmin G1000 avionics suite with an integrated Garmin GFC700 autopilot system.

Course Descriptions. The AVIA 320 Instrument Flight course provided basic instrument flight training leading to an FAA Instrument Rating. The course required approximately 35 hours and included a combination of both aircraft and simulator flight training. The student gained an in-depth knowledge of Air Traffic Control procedures, airway navigation, and both precision and non-precision instrument approaches. AVIA 320 was designed to prepare students for the FAA Instrument Practical Test. AVIA 320 supported Appendix A: TCO Common Information and the Instrument Airplane TCO of the host university's FAA-approved CFR Part 141 flight training program. The instrument pilot TCO provided CFIs with general course knowledge objectives and common flight training tasks used within each AVIA flight course by the host university. Background information on those objectives and tasks is provided in Appendices A and C Of note, the FAA approved instrument pilot rating TCO for the host university contained 32 mandatory and 4 optional training units. Each unit consisted of a preset number of lesson line items with the number of line items varying between lessons / units.

AVIA 325 Commercial Flight I was the first of three, sequential, flight training courses that included the requisite aircraft and simulator training and experience required for the FAA Commercial Pilot practical evaluation. In AVIA 325, students were required to complete approximately one third of the aircraft and simulator training and experience hours required in the host university's commercial pilot TCO.

AVIA 326 Commercial Flight II was the second of three sequential flight training courses that included the requisite aircraft and simulator training and experience required for the FAA Commercial Pilot practical evaluation. In AVIA 326, students were required to complete approximately one third of the aircraft and simulator training and experience hours required in the host university's commercial pilot TCO.

AVIA 327 Commercial Flight III was the third of three sequential flight training courses that included the requisite aircraft and simulator training and experience required for the FAA Commercial Pilot practical evaluation. In AVIA 327, students were required to complete approximately one third of the aircraft and simulator training and experience hours required in the commercial pilot TCO.

Combined, AVIA 325, 326, and 327 prepared students for the FAA commercial practical examination. Furthermore, each of these flight courses was designed to provide essential and required ground, simulator, and flight training in accordance with the FAA approved commercial pilot certificate TCO. Additionally, the commercial pilot certificate TCO provided CFIs with general course knowledge objectives and common flight training tasks used within each AVIA flight course. Background information on these objectives and tasks is provided in Appendix B and D. Of note, the FAA approved commercial pilot certificate TCO for the host university contained 63 mandatory ground, FTD, and airplane training units. Each unit was comprised of a preset number of lesson line items with the number of line items varying between lessons / units.

The archival records extracted for this study included line item RPL performance assessments provided by the student's assigned flight instructor. Upon successfully meeting each line item minimum RPL within a lesson, the student became eligible to advance to the next lesson in the TCO. Additionally, archival data provided a summary of time used by the instructor and student for each completed lesson within each course.

Procedures

Research methodology. This study used an effect-type ex post facto design. This design was appropriate because the study sought to examine what was the effect of group membership on the dependent variable using events that had already taken place. I sought to determine substantive and statistically significant effects of type of private pilot flight training on a group of private pilots who subsequently completed additional flight training. The group membership of this study consisted of two pre-existing groups of pilots: pilots who had completed private pilot training in a residential collegiate flight program (CTPs) and pilots who had completed private pilot training in a non-collegiate flight program (NCTPs). This study hypothesized that pilots belonging to the NCTP group would not perform as well in and would require additional time to complete the first two flight courses (i.e., Commercial Flight I and Instrument Flight) after obtaining a private pilot certificate at a residential collegiate program as pilots who belonged to the CTP group. In the third and fourth flight courses (i.e., Commercial Flight II and Commercial Flight III), there would be no difference in pilot performance or time spent observed between pilot groups. The relationship between independent variable group membership and dependent variable measurements was provided in Figure 1.1. Because I utilized census data collected over a five-year period from the host university flight training program, selection bias associated with the independent variable pre-existing groups was not applicable.

Human subject research. Although this study did not involve direct communication or interaction with human subjects, it did utilize the individual flight training records of collegiate flight students. Therefore, to ensure compliance with the ethical principles of human subject research and to adequately protect both the data and students who generated the data, I followed and complied with the established research policies, procedures, and practices prescribed by the host university's Office of Research Ethics (a.k.a. Institutional Review Board) and the Institutional Review Board (IRB) of Florida Institute of Technology (FIT). In fulfillment of both the host university and Florida Institute of Technology IRB application process, I completed the Collaborative Institutional Training Initiative (CITI) Program training related to Social and Behavioral Research on September 7, 2020. Additionally, as part of the IRB process, I submitted a "Faculty Application for Research Involving Human Subjects" form to the host university's IRB. The host university IRB number was IRB-FY20-21-142. The host university IRB determined that the planned research did not meet the definition of Human Subjects research because the study did not involve the collection of subject specific identifiable and / or private information. On December 18, 2020, the host university IRB issued the research approval letter, provided as Appendix E. Subsequent to receiving research approval from the host university, I submitted a "Research Involving Human Participants Exempt Application" form to the Florida Institute of Technology's IRB. The Florida Institute of Technology IRB reviewed and approved the exempt application after determining the study presented minimal risk to human subjects. On February 4, 2021, the Florida Institute of Technology IRB issued an indefinite *Notice of Exempt Review Status and Certificate of Clearance for Human Participants Research* for IRB number 21-014, provided as Appendix F.

Confidentiality of subjects was safeguarded and ensured through a rigorous de-identification process and remained fully compliant with the IRB policies of both the host university and the Florida Institute of Technology. The student collegiate flight records used during this study were located on a password protected secure network owned and maintained by the host university. Those records were the archived student flight records that encompassed the proposed study period. Access to the archived student records was limited to university leadership and key staff members through a password protected and centrally managed secure network via an ARGOS reports program provided and maintained by the host university. Datasets were extracted from the archived data base in the form of manipulatable spreadsheets. For purposes of this study, an independent host university database SME extracted the appropriate and applicable datasets into a spreadsheet that was then saved in a password protected, personal folder on the same centrally managed secure network as the archived database. A separate Excel spreadsheet codebook file was used to connect names found in the raw datasets with an individually assigned record number that was used in the de-identified datasets. The codebook file was maintained in a separate password protected private folder on the host university's secure network. The host university's flight training SME, the school's Executive Assistant, and the school's Dean were the only individuals with access to the codebook file. After extracting and saving the applicable datasets to the password protected personal folder on the university's secure network, the designated staff member assigned each record a unique record number as annotated in the codebook. After each student flight record was assigned a subject number, the flight training SME then deleted all personally identifiable data from the dataset. Personally identifiable data included (but was not limited to) the student's name, university identification number, address, phone number, birthdate, pilot certificate number, or any other similar information that was unique to an individual. After all of the identifying information was removed, the dataset was then saved to a separate password protected personal Dropbox folder and provided to the principal researcher of this study for analysis using SPSS and further review by the co-investigator approved by both IRBs. At no time was any data containing any personally identifiable information saved or located on a computer that was not either connected to the host universities' secure network either directly or via a Virtual Private Network (VPN) connection. Furthermore, the de-identified datasets were only viewed by individuals identified and approved as a co-investigator by both IRBs. Descriptive and inferential statistics including analysis, assessment, findings, and conclusions of the de-identified data are presented in aggregate in chapter 4 and 5 of this dissertation. In some instances, students whose data was included in the archived database were still students with host university. Inadvertent encounters between the principal researcher and students whose records were used in the research occurred. In those instances, all discussions were general and aggregate in nature without specific or direct reference to any individual recorded performance or inclusion in the study.

Description of independent and dependent variables. This study included one IV and sixteen dependent variables (DVs). The IV in the study was the type of private pilot flight training an individual experienced and completed when obtaining a private pilot certificate (i.e., CTP or NCTP). Dependent variables were Y_1 = pilot performance in AVIA 325, Commercial Flight I; Y_2 = ground time required to complete AVIA 325, Commercial Flight I; Y_3 = flight time required to complete AVIA 325, Commercial Flight I; Y_4 = pilot performance in AVIA 320, Instrument Flight; Y_5 = ground time required to complete AVIA 320, Instrument Flight; Y_6 = flight time required to complete AVIA 320, Instrument Flight; Y_7 = pilot performance in AVIA 326, Commercial Flight II; Y_8 = ground time required to complete AVIA 326, Commercial Flight II; Y_9 = flight time required to complete AVIA 326, Commercial Flight II; Y_{10} = pilot performance in AVIA 327, Commercial Flight III; Y_{11} = ground time required to complete AVIA 327, Commercial Flight III; Y_{12} = flight time required to complete AVIA 327, Commercial Flight III.

Additional data was provided by the host university that permitted analysis of any potential differences between pilot groups in the number of lesson attempts required to complete each semester course. These data included four additional DVs discussed in the Supplemental Analysis section of this Chapter. Additional DVs were Y_{13} = lesson attempts required to complete AVIA 325, Commercial Flight I, Y_{14} = lesson attempts required to complete AVIA 320, Instrument Flight, Y_{15} = lesson attempts required to complete AVIA 326, Commercial Flight II, Y_{16} = lesson attempts required to complete AVIA 327, Commercial Flight III.

For purposes of this study, group membership resided within the nominal IV as the FAA type of flight training, either residential collegiate or non-collegiate, that a student experienced during private pilot training. The continuous DVs Y_1, Y_4, Y_7, and Y_{10} were determined as the sum of the CFI assigned RPL scores for every line item in each lesson first attempt within each flight course. To derive the sum of

CFI assigned RPL scores, every line item RPL score for every first attempt lesson within each course was collected and summed. The RPL scores for any repeated or additional lesson(s) were not included in the calculation. A hypothetical example of that process follows: AVIA 325 lesson number 1 had 8 TCO required line items and the student demonstrated a RPL score of 1 for each line item. The sum of the RPL scores for lesson number one would have been eight. AVIA 325, lesson number two had 20 TCO required line items and the student demonstrated a RPL score of two for each line item. The sum of the RPL scores for AVIA 325, lesson number two would have been 40. AVIA 325, lesson number three had 15 TCO required line items and the student demonstrated a RPL score of four for each line item. The sum of the RPL scores for AVIA 325, lesson three would have been 60. The collection and summation of the demonstrated RPL scores for each lesson would continue until the sum of the RPL scores for each of the required lessons within a course were collected. In the current study, the RPL scores for every lesson within each commercial course (e.g., AVIA 325, AVIA 326, and AVIA 327) and the instrument course (AVIA 320) were summed in this manner.

When a student, in attempting a lesson, required additional time or attempts to complete the required line items, the allotted training lesson lab time limit may have been reached. At that time, if the instructor was not able to coordinate for a training lab time extension, the instructor was then required to end the lesson prior to the student achieving the RPL score for that line item as well as any other incomplete or not attempted line items remaining in that lesson. As such, when a student was unable to attempt every line item in a lesson, the line item associated RPL was graded as either *Not Observed* or *Not Attempted*. For purposes of this study, to accurately account for the substandard performance when attempting or completing the achieved line items in a completed lesson had on the overall lesson performance that resulted in either a *Not Observed* or *Not Attempted* line-item grade, an equivalent score of zero (0) was assigned for each *Not Observed* or *Not Attempted* line item. Every first attempt lesson RPL sum was then summed together for a combined total RPL sum for each commercial course and the instrument course. As a result, the overall RPL sum for every first attempt lesson relative to the overall minimum RPL sum was reduced. A reduced or lower first-time RPL sum represented poorer demonstrated performance.

In some instances, changes in weather conditions or mechanical issues arose during a student's flight training lab that necessitated an early termination of the flight lesson. Lesson termination rates due to weather were expected to be very minimal due to established conservative weather training minimums enforced through real-time monitoring of weather conditions by a dedicated flight operations staff and supervisor of flying (Appendix G). Likewise, lesson termination rates due to mechanical issues were also expected to be very minimal due to the relative high reliability rate of approximately 75% with the use of a relatively modern fleet of aircraft owned and operated by the host university.

The continuous DVs Y_2, Y_5, Y_8, and Y_{11} were determined as the difference in ground time, to the nearest tenth of an hour, between the amount of ground time required for successful completion of each flight course and the minimum ground time required by the respective TCO, conducted within each lesson of the course. The use of the difference between the actual ground time used and the TCO ground time required provided the best measurement of ground time discrepancies between a student's actual performance and the student's desired performance (i.e., the TCO course requirements) while accounting for the FAA minimum number of ground hours specified and required in each TCO and also accounted for any slower than expected or desired learning. To account for any variance in TCO ground time requirements between courses, the minimum ground training time required by the respective TCO to complete each lesson of each course (e.g., AVIA 325, AVIA 320, AVIA 326, AVIA 327) was subtracted from the summed amount of ground time a student needed to successfully complete each lesson of each course. The difference between the actual ground time needed to successfully complete the course minus the minimum required ground time represented a student's additional time required beyond the TCO minimums within each course. Students requiring more standardized ground time to complete a course demonstrated slower training times, whereas students who completed all the required course ground requirements in a shorter period of standardized time demonstrated faster training times. A hypothetical example of that process follows: a student in AVIA 325 had 13.0

hours of TCO required ground time but required 14.0 hours of ground time to successfully complete the course requirements. The difference between the total ground time needed to complete the course (14.0) minus the minimum ground time required, per the TCO (13.0) provided a standardized difference of plus 1.0 hours. Therefore, this student required 1.0 hour of additional ground time to successfully complete the AVIA 325 course requirements. This student's 'plus 1.0' difference score would be included with all of the other standardized differences from the student records of the same IV group membership category (i.e., CTP or NCTP) for data analysis in the AVIA 325 course. This process was completed for every student record, in every course, spanning the entire study period.

Within each TCO, flight time was defined as the sum of both flight training device (a.k.a. FTD or simulator) time and actual aircraft time. Additionally, each TCO specified a minimum number of aircraft time required and a maximum percentage of FTD time permitted for course completion. Thus, the total flight time required by each TCO could be satisfied through use of a FTD for some specified lessons, and the instruction time acquired in the FTD was credited toward the flight time requirement of the flight course and TCO. Therefore, for purposes of this study, flight time includes both FTD and aircraft time.

The continuous DVs Y_3, Y_6, Y_9, and Y_{12}, were determined as the difference in flight time, to the nearest tenth of an hour, between the flight time required for successful completion of each flight course and the minimum flight time required by the respective TCO conducted within each lesson of the course. The use of the difference between the actual flight time used and the TCO flight time required provided the best measurement of flight time discrepancies between a student's actual training time and the student's desired training time while accounting for the FAA minimum number of flight hours specified and required in each TCO and also accounting for any slower than expected or desired learning. To account for any variance in TCO flight time requirements between courses, the minimum flight training time required by the respective TCO to complete each lesson of each course (e.g., AVIA 325, AVIA 320, AVIA 326, AVIA 327) was subtracted from the summed amount of flight time a student needed to successfully complete each lesson of each course. The difference between the actual flight time needed to successfully complete the course minus the minimum required flight time represented a student's flight time within each course. Students requiring more standardized flight time to complete a course demonstrated longer training times, whereas students who completed all the required course flight requirements in a shorter period of standardized time, demonstrated a shorter training time. A hypothetical example of that process follows: a student in AVIA 325 had 23.6 hours of TCO required flight time but required 29.3 hours of flight time to successfully complete the course requirements. The difference between the total flight time needed to complete the course (29.3) minus the minimum flight time required, per the TCO (23.6) provided a standardized difference of plus 5.7.

Therefore, this student required 5.7 hours of additional flight time to successfully complete the AVIA 325 course requirements. This student's 'plus 5.7' difference score would be included with all of the other standardized flight time differences from the student records of the same IV group membership category (i.e., CTP and NCTP) for data analysis in the AVIA 325 course. This process was completed for every student record, in every course, spanning the entire study period. Note that for each of the three commercial flight courses, the standardized times for ground and flight time might be negative, indicating completion in less than the TCO allocated time. This is permissible as long as the total TCO time minima were met prior to the completion of the last course identified within the TCO (i.e., the sum of all actual ground or flight training for the commercial certificate, across all three commercial courses, should be at the minima).

The supplemental, continuous DVs Y_{13}, Y_{14}, Y_{15}, and Y_{16} were determined as the difference in the actual number of training lessons completed in this course minus the minimum number of training lessons required in this course per the TCO requirements. The use of the difference between the actual number of lessons completed and the TCO lessons required provided the best measurement of lesson number discrepancies between a student's actual training sessions and the student's desired training sessions while accounting for the FAA minimum number of lessons specified and required in each TCO and also accounting for any slower than expected or desired learning. To account for any variance in TCO lesson number requirements between courses, the minimum number of lessons required by the respective TCO to complete each course (i.e., AVIA 325, AVIA 320, AVIA 326, AVIA 327) was subtracted from the number of lessons a student needed to successfully complete each course. The difference between the actual number of lessons needed to successfully complete the course minus the minimum required number of lessons represented a student's overage of lessons within each course. Students requiring more standardized lessons to complete a course, demonstrated slower training, whereas students who completed all the required course requirements in fewer standardized lessons, demonstrated accelerated training. A hypothetical example of that process follows: a student in AVIA 325 had 20 TCO required lessons but required 23 lessons to successfully complete the course requirements. The difference between the number of lessons needed to complete the course (23) minus the minimum number of required lessons, per the TCO (20) provided a standardized difference of plus 3. Therefore, this student required three additional or repeated lessons to successfully complete the AVIA 325 course requirements. This student's 'plus 3' difference score would be included with all of the other standardized lesson count differences from the student records of the same IV group membership category (i.e., CTP and NCTP) for data analysis in the AVIA 325 course. This process was completed for every student record, in every course, spanning the entire study period.

Study implementation. Coordination with the host school's Dean was accomplished and the flight records SME who had direct access to five years of digitized, collegiate student, flight records, and data that supported this research. Prior to requesting the deidentified data used for this study, I ensured final IRB approval from both the host university and FIT were received (see Appendices E & F). All requirements established by both IRBs were complied with. Subsequent to both IRB approvals and my research committee review and approval, I was provided the deidentified archived flight records dataset. All students whose training records indicated successful completion AVIA 225 were identified with CTP independent variable group membership (residential college). All other records were identified with NCTP (non-collegiate program) independent variable group membership.

Threats to internal validity. Internal validity refers to the extent to which changes in the DV could be directly and solely attributed to the independent variable. In the context of this study, internal validity depended on the extent to which group membership was related to any statistical variances observed in the DV. Ary et al. (2010) identified 11 threats to internal validity: history, maturation, testing, instrumentation, statistical regression, selection bias, experimental mortality (attrition), selection-maturation interaction, experimenter effect, subject effects, and diffusion; location is identified as an additional threat. These potential threats, their relevance to the current study, and how they were minimized is provided below.

History. History refers to specific events or conditions other than the treatment that may have occurred between the beginning of the treatment and the posttest measurement and may have produced changes in the dependent variable (Ary et al., 2010). Those events may have been major political, economic, or cultural events that occurred at the same time the treatment was applied. For example, there may have been major changes in the FAA evaluation standards, policies, and procedures that would affect (increase, decrease, or negate) the RPLs associated with each line item found in the FAA approved TCOs. Because the current study design is an ex post facto design, changes in the dependent variable have already occurred and thus cannot be controlled.

Beginning in 2016, the FAA began a multiyear phased restructuring of the aeronautical knowledge, flight proficiency, and risk management airman certification system. Restructuring included development, distribution, and implementation of ACS as a replacement of existing PTS. The goal of the FAA in developing and implementing the ACS was to synchronize the components of the airman certification system and establish a systematic approach that fully integrated the FAA safety management system (SMS). The four functional components of the FAA SMS included safety policy, risk management, safety assurance, and safety promotion (FAA, 2018). Implementation of the ACS began with release of the

Private Pilot – Airplane ACS and the Instrument Rating – Airplane ACS on June 1, 2016 (FAA, 2018). The Commercial Pilot – Airplane ACS was released approximately one year later on June 12, 2017 (FAA, 2018). Although the transition from PTS to ACS was considered a substantive change in FAA regulatory and certification guidance at that time, training standards within the host university's TCOs remained relatively unchanged and standardized while continuing to prepare flight students to meet or exceed the standards specified in the ACS.

Additionally, the Corona Virus Disease 2019 (COVID-19) global pandemic significantly disrupted the standardized flight training environment. Numerous protective and preventative measures were implemented as the spread of the virus became more prevalent. As the virus reached pandemic status, the host university was mandated by an executive order issued by the governor, to stop all face-to-face higher education, including flight training. That order was in place for approximately 12 weeks and prohibited any face-to-face flight training. To ensure no adverse effects from the COVID-19 outbreak influenced the data used in the current study, it was determined via email records that the first record of any additional cleaning or screening protocols occurred on / about March 17, 2020. Therefore, to ensure an adequate buffer for any undocumented COVID-19 concerns that may have affected flight training but remained undocumented, any and every course including a training record with any logged activity after March 1, 2020 was excluded from the data analysis.

Maturation. Maturation refers to biological or psychological changes within the subjects that may have occurred over time. For example, subjects may have performed differently on the dependent variable because they were older, wiser, more fatigued, or less motivated (Ary et al., 2010). Although a maturation threat usually is more applicable to studies involving children because of their high maturation rate, it may have been applicable to the current study with respect to the maturity level development of collegiate students from the first year, freshman status and perhaps living on their own for the first time in their life, to the fourth-year senior who had developed, matured, and was then prepared to function as a productive member of society as a professional aviator. Although the maturation of collegiate students could have been substantial in the four years of college, the expected timespan of collegiate flight training matched the number of courses required by the student to complete the Degree Completion Plan (DCP) associated with the student's declared degree major. Additionally, the maturation of collegiate students was a natural occurrence that affected every student while attending college and did not prohibit or limit further training as a result of maturing out of the study group. As such, maturation of subjects in this study was not a concern.

Testing. The testing effect, or pretest sensitization, refers to the influence a pre-assessment might have had on a participant's performance on a post-assessment regardless of any treatment. Individuals may have performed better on a post-assessment as a result of their pre-exposure to the items on the assessment, the format of the assessment, the testing environment, or because they were able to develop a strategy to perform better on a second assessment (Ary et al., 2010). The student activities observed in the current study were knowledge- and performance-based activities evaluated by a CFI using the approved course TCO line items and lesson RPLs as the assessment instrument. As such, although the student knowledge and performance were practically assessed each lesson and provided the CFI a training progress measurement of the student, each TCO was designed to provide a building block series of lessons that built upon the activities of previous lessons. Therefore, it was the design and intent of the TCO that a student's performance should have improved with each lesson and assessment. Therefore, testing effect was not a validity threat to the current study.

Instrumentation. An instrumentation threat refers to changes that may have occurred in the manner by which a dependent variable was measured from the first time to the second or subsequent time and may bring about the observed outcome rather than the treatment itself (Ary et al., 2010). An instrumentation threat may also be posed when the reliability of the instrument used was in question. Instrumentation threats may have also been related to instrument decay, data collector characteristics, and / or data collector bias as described below.

Instrument decay. Instrument decay refers to changes made to an instrument over the course of the study or differing interpretations of the results of an instrument. A potential instrument decay instrumentation threat may have existed in the proposed study if any substantive and significant changes occurred in the FAA approved TCOs used as the basis and standard instrument for data collection in each course. For purposes of this study, a line-item-by-line-item review of each lesson in each stage of the Commercial and Instrument TCOs was conducted to determine if any substantive or significant changes occurred between TCO revisions during the period of study. The large majority of changes between TCO revisions were administrative in nature, detailing administrative changes in the organization personnel structure or administrative changes in TCOs, such as changes in TCO page numbers or other non-substantive changes such as refinement of lesson prerequisites and permitted destination airports. In several instances, changes between TCO revisions indicated a change or adjustment in the required number of lessons within a TCO stage and / or a change in the required amount of training time within a TCO stage. In order to account for and mitigate the impact of any variation in the number of lessons within each TCO stage between courses the difference between the total number of lesson attempts (including addition and / or repeated lesson attempts) and the minimum number of lessons required by each respective TCO was used for analysis. Similarly, in order to account for and mitigate any variation in the amount of time within each TCO stage between courses the difference between the amount of time actually used to complete all the lesson in each stage (including additional and / or repeated lesson times) and the minimum amount of time, as specified by each TCO, to complete all the lessons within each TCO stage was used in the analyses.

Data collector characteristics. Data collector characteristics refer to specific characteristics of the data collector, such as gender, age, and ethnicity, and how the dependent variable may have been impacted if those characteristics changed. The data used in this study was recorded by FAA Certified Flight Instructors (CFIs) and then verified by each flight student subsequent to each lesson. The demographics of the flight instructors employed by the university during the study period were similar to the student population with over 95% of the instructors employed by the university having been either a current student who had obtained their CFI certificate or having been a recent graduate of the host university's aeronautics program. Every CFI employed by the university was required to complete CFI new hire indoctrination training that was conducted by the FAA designated chief instructor pilot and the assistant chief instructor pilots for each TCO that the new hire CFI provided instruction in. Prior to the new hire CFI being permitted to provide any instruction to any student, the new hire CFI was required to successfully pass an oral and practical CFR Part 141 examination conducted by the Chief Instructor or one of the Assistant Chief Instructors for the TCO being considered. Upon successful completion of the oral and practical examinations, the chief instructor pilot certified the new hire CFI to provide instruction in accordance with the standards specified in the applicable TCO(s). Furthermore, when an instructor was selected to provide instruction in one of the other approved TCOs offered by the host university, the training and certification process was once again completed under the direction of the applicable Chief Instructor for the additional TCO. Additionally, every year each flight instructor was required to recertify in every TCO they were certified to provide instruction in, at the time of the annual certification renewal. The recertification process included an oral and practical evaluation similar to the initial certification process. Therefore, any variation in other data collector characteristics was mitigated by the FAA mandated standardization and certification of every CFI across the entire host university instructor corps.

Data collector bias. Data collector bias oftentimes refers to inconsistent administration of an instrument by the data collector or the distortion of data by the collector or the scorer. This threat is most commonly associated with the administration of a standardized test by different individuals to different groups. For the current study, the data was compiled over a five-year period by numerous CFIs. To mitigate potential data collector bias concerns, a review of the CFI training and certification process has been provided. As described in the preceding section, every CFI employed by the host university was required to complete CFI new hire indoctrination training and was certified in each assigned TCO prior to providing any student instruction. Furthermore, every year, each flight instructor was required to recertify in each TCO they had previously been certified to provide instruction in. The certification renewal process included an oral and practical evaluation similar to the initial certification process. The rigorous initial certification process with recurring qualification and certification renewal requirements across each of the TCOs minimized data collector bias as a potential threat to the current study.

Statistical regression. Statistical regression refers to the tendency for extremely high or low scorers on a pre-assessment to regress toward the mean on a post-assessment. Statistical regression may have been a threat if extremely high or low scorers were selected from a group because the subgroup would have tended to score less extremely, even during a retest. As described earlier in the testing effect section, the student activities observed in the current study were knowledge- and performance-based activities evaluated by a CFI who used an approved course TCO line item and lesson RPLs as the assessment instrument. As such, each TCO was designed to provide a building block series of lessons that built upon the activities of previous lessons. Therefore, it was the intent of each TCO design that a student's performance would improve with each lesson and assessment. Therefore, the current study was not susceptible to statistical regression.

Selection bias. Selection bias refers to the threat posed by nonrandom factors that may have influenced the selection of participants and would have resulted in differences between the treatment and control groups even before the experiment began. Selection bias was not applicable to this study because the study employed a census sampling of the population of the host university's flight students between 2015 and 2020.

Mortality. Mortality refers to the loss of participants (attrition) during the implementation of a study and may have been a concern due to the loss of specific types of participants that could have impacted the outcome of the current study. Attrition (failure) rate of flight students varied between flight courses. Student course failures were documented and reported in aggregate with the associated IV group and DV course.

Selection-maturation interaction. The selection-maturation interaction threat refers to the combined influence of identifying and selecting participants who may have had specific characteristics that result in a more advanced maturation rate than another group over the course of a study. The interaction between selection and maturation may be mistaken for a treatment effect. Selection-maturation threat is generally not a concern in ex post facto studies and because this study used census data, selection-maturation interaction threat had negligible effect on the analysis or findings of the current study.

Experimenter effect. An experimenter effect refers to the effects that a researcher had on a study related to his / her personal characteristics, such as age, gender, level of education, and unintended biases. Unintended biases may have influenced the performance of participants in a study if the researcher had been more enthusiastic in the treatment group than the control group. Generally, this type of threat is not a concern in ex post facto studies because there has been no study intervention. Therefore, the experimenter effect threat was not applicable to this study.

Subject effects. Subject effects refer to the changes in the attitudes of the participants in a study that may have influenced the results of the study. When participants in a treatment group respond to the increased attention of the study and alter their performance, the resulting change in performance and study results is referred to as the Hawthorne effect. Conversely, when individuals in the control group alter their behavior or attitude in the study as a result of the increased attention given the treatment group, the resulting change in the study results is referred to as the John Henry effect. Because the current study design is an ex post facto design, there was no experimental intervention. Additionally, at the time the data was observed and collected, there was no established study or awareness of a projected study for subjects or observers to be influenced or affected by a compensatory rival subject effect such as the Hawthorne or John Henry effect. Therefore, the subject effects threat was not applicable to the current study.

Diffusion. Diffusion refers to any intentional or unintentional inter-subject communication of information about the study’s treatment to other subjects in the control group that may have influenced subjects in the control groups response, behavior, or performance. As a result of inter-subject communication, the treatment and control groups may have performed similarly on the dependent measure. Diffusion threats are not applicable to ex post facto designs and therefore did not have any impact on the current study.

Location. The location threat refers to changes in the setting in which a study takes place that may have influenced the results. The location of all flight training in the current study was regulated by the CFR Part 141 approved TCOs and thus were standardized for each and every individual. Furthermore, each of the flight briefing rooms, flight training devices (simulators), and aircraft were standardized with identical configurations and capabilities across each training environment, device, and aircraft. Additionally, all the data was from a single residential collegiate aeronautics program that operated out of a single base of operations located in the mid-Atlantic region of the United States. As such, the location threat was considered negligible for the current study's data set.

Treatment verification and fidelity. Every residential collegiate flight student record collected from the host university's residential flight training program between August 2015 and August 2020 was considered for the current study. Within the timeframe and scope of this study, it was the host university's policy to accept flight students into the university's residential flight training program who had previously participated in or had completed various levels of flight training. When a flight student had previously successfully satisfied all the

FAA knowledge, oral, and practical examinations and had been awarded an FAA certificate or rating (private, commercial, or instrument), the host university would award academic credit for those previous accomplishments and permit the student to begin the university residential flight training program at a commensurate level as had been previously demonstrated through the provided FAA certificate(s) or rating. For example, in the current study 208 students had completed their private pilot certificate prior to beginning the university residential flight training program. For the students who had previously been awarded a private pilot certificate, the university awarded academic credit for private pilot ground and flight training courses, which satisfied the prerequisites for the student to begin commercial flight training in Commercial Flight I (AVIA 325). When accessing the archived flight records database, students who had previously obtained their private pilot certificate prior to beginning flight training in the university's residential flight program did not have any private pilot flight training records recorded with the university, and their first flight course recorded by the university was Commercial Flight I for students who were registered in either the Commercial / Corporate or the Global Studies degree programs.

Every student who had not completed all the FAA evaluation requirements for a private pilot certificate and had not been awarded a private pilot certificate was required to register and complete all the applicable private pilot ground and flight training to receive academic credit and then continue with the additional flight courses needed for degree completion. Specifically, every student who did not already hold a private pilot certificate was required to register and subsequently successfully complete the two private pilot ground courses AVIA 210 and AVIA 215. After successfully completing both ground courses, the student was then permitted to enter the university's residential flight training program beginning with Private Pilot Flight I (AVIA 220) and Private Pilot Flight II (AVIA 225). The FAA knowledge examination was completed at the end of AVIA 215 and the FAA oral and practical examinations were then completed at the end of AVIA 225. The issuance of an FAA private pilot certificate by the FAA was required prior to any student beginning the next flight course within their respective degree completion plan.

Each of the host university's Private, Commercial, and Instrument Pilot flight courses were conducted under CFR Part 141 rules and regulations as outlined in each FAA approved TCO. Thus, every student who participated in any of the host university's approved residential flight courses within the Private, Commercial, or Instrument Pilot TCOs was being instructed under and in accordance with CFR Part 141 rules and regulations.

Conversely, students who completed their private pilot flight training prior to beginning flight training at the study university completed their training under either CFR Part 61 or Part 141 certification standards as applicable to the flight school or instructor where they obtained their training and certification. Thus, students who began the host university's residential flight training program may have completed their private pilot flight training under CFR Part 61 or Part 141. Additionally, the same students did not have any private pilot flight training records maintained in the host university's archived flight records database. Therefore, any student flight record found in the host university's archived record database that did not include any private pilot flight training was categorized as a non-collegiate program trained student record.

Data Analysis

Data analysis was accomplished through the use of descriptive and inferential statistics.

Descriptive statistics. Descriptive statistics were used to report the total number of participants, their training experience, general trends in the data, and other pertinent information. These statistics were calculated from records in the archived student flight records database. The data pulled from the database was in the form of an Excel spreadsheet suitable and available for data analysis. Data analysis was conducted using International Business Machines (IBM) Statistical Package for the Social Sciences (SPSS) Statistics, version 25. The statistics included the number of CTPs, the number of NCTPs, the aggregate performance descriptive statistics within each course and between CTP and NCTP groups including the mean, mode, median, range, and standard deviation for each dependent variable overall and within each pilot group during the study period.

Inferential statistics. The three inferential statistic procedures utilized in the current study were: independent-samples *t* test, one-way MANOVA, and Mann-Whitney U test.

Independent-samples* t *test. The first inferential statistic used was an independent-samples *t* test. The independent-samples *t* test was used to determine if a difference existed between the mean pilot performance (RPLs) of CTPs and NCTPs. The independent-samples *t* test procedure was performed using SPSS, version 25.

There were five assumptions associated with conducting an independent-samples *t* test. First, independence of observations seeks to ensure that each DV observation is independent of all other observations. The data was stored in a secure database with personally identifiable information required by the FAA for flight training record keeping. Records were verified as individual records by the database SME. Second, the categorical IV assumption ensures a distinction between IV groups when analyzing each DV to determine the presence of any effects. Prior to deidentification of the dataset, the database SME conducted a data search of each flight training record for evidence of completed private pilot training at the host university. Student flight records in the MFT and legacy ETA data management systems were accessed as a part of the search. Students with no host university record of completing residential collegiate private pilot training were categorized as NCTP. Third, the continuous DV assumption is concerned with the measurement of the DV values on a continuous level. Lesson time DVs used in the current study were measured on a continuous scale. Fourth, the normal distribution assumption is concerned with the normal distribution of data. Normality was determined using a Shapiro-Wilk normality test in SPSS, version 25. Finally, homogeneity of variances is concerned with measuring variances across residual values regardless of the IV values. Homogeneity of variances was determined using the Levene's test for equality of variances in SPSS, version 25.

One-way MANOVA. The second inferential statistical procedure was a one-way MANOVA procedure conducted in IBM SPSS, version 25. The MANOVA procedure was an extension of the univariate ANOVA and extended the ANOVA analysis by taking into account multiple continuous dependent variables by bundling them together into a weighted linear combination or composite variable. The MANOVA model used *F*-statistic numbers by dividing the means sum of the squares (SS) for the source variable by the source variable mean error (Tabachnick & Fidell, 2012). The MANOVA compared whether or not the newly created combination differs by the multiple groups or levels of the independent variable. As such, the MANOVA examined whether or not the independent grouping variable simultaneously explained a statistically significant amount of variance in the dependent variable. To perform the MANOVA procedure in SPSS, I used the Multivariate, General Linear Model, Analysis option.

There were five assumptions associated with conducting a MANOVA. First, there had to have been an independent random sampling. This assumption was met in the proposed study because a census of the available population was used. All of the subjects were flight students from a mid-Atlantic Region collegiate aviation program between the years 2015 and 2020. The second assumption was that the IV is categorical and the DVs were continuous or scaled variables. This assumption was met with the IV being the category of type of private pilot flight training experienced by the study's population and the student time spent DVs having been measured continuously against TCO required time. The third assumption was that there must be an absence of multicollinearity that required each dependent variable be independent and not highly correlated to each other. Although this assumption is likely met because each collegiate flight course is independent of each other, it is possible that student performance may be correlated among flight courses. As such, the data will be tested for multicollinearity when made available. Students at the host university were not permitted to be registered in two flight courses at the same time. Thus, a student's participation in each flight course was independent of all other flight courses and each flight course was conducted independently (not at the same time) of all other flight courses. The fourth assumption was that multivariate normality had to be present in the data. Normality was determined using a Shapiro-Wilk normality test in SPSS, version 25. The fifth assumption was that there is homogeneity of variances, which indicated that variances between groups was equal. Homogeneity of variances was determined using the Levene's test for equality of variances in SPSS, version 25.

In addition to verifying and analyzing the assumptions of a MANOVA, the effect size of the statistics and how much variance could be explained by the independent variable was examined using a partial eta squared (η^2). Finally, post hoc tests were conducted to determine where statistically significant differences were between groups.

Mann-Whitney U Test. The third inferential statistical procedure in the current study was a Mann-Whitney U test procedure conducted in IBM SPSS, version 25.

The Mann-Whitney U test is a rank-based nonparametric test that was used to determine if there were differences between CTP and NCTP groups on the number of lesson attempts required in each course; this test was used for the supplemental analyses. The Mann-Whitney U test procedure was performed using SPSS, version 25.

There were four assumptions associated with conducting a Mann-Whitney U test. First, independence of observations seeks to ensure that each DV observation is independent of all other observations. As previously described, the records were verified as individual records by the database SME. Second, the categorical IV assumption ensures a distinction between IV groups when analyzing each DV to determine the presence of any effects. As previously described, the database SME verified the type of private pilot flight training for each record. Third, the continuous DV assumption is concerned with the measurement of the DV values on a continuous level. Lesson attempts DVs used in the current study were measured on a continuous scale. Finally, the shape of DV group distributions is concerned with determining the shape of the distribution of data. Data that has the same shape of distribution of the DV for both groups permits comparison of medians and mean ranks. To determine the shape of each DV group distribution, a visual inspection of the data using histograms was conducted.

Chapter 4

Results

Introduction

This chapter is organized and presented in three main sections. The first section contains a summary of the descriptive statistics related to the archived student flight training records used in this study. The second section provides a review and summary of assumptions and predictions. The third and final section of this chapter provides inferential statistics derived from the data.

Dataset Preparation.

The data used in the current study were collected from archival flight training records of a collegiate aeronautics program located in the Mid-Atlantic Region of the United States. Archived data was retrieved from the proprietary secure database maintained by the university's information technology department. The study collected data from the records of students who had completed flight training at the host university during the period between August 2015 and August 2020 (inclusive). The use of archival data for this study permitted timely access to five years of flight training data and provided a dataset large enough to achieve adequate power. Use of the archived database provided a sufficient dataset to observe an adequate number of student records with numerous measurements in commercial and instrument flight training over a five-year period. It was noted during a review of each TCO in effect during the study period that no major revisions or rewrites occurred to either the commercial or the instrument TCOs.

Within the accessible database, student flight and performance records spanned a period as brief as one collegiate semester (approximately a three-month observation period) per student to as long as five college semesters (or more if the student failed to progress in the course and had to repeat the course a second semester; approximately a fifteen-month observation period).

Data Validity Check. Initial actions after receiving the dataset included completion of a data validity check to ensure the accuracy and quality of data. Validity check process details are provided in the following section.

Redundant records. Upon initial review of the deidentified dataset, 36 redundant records were found. In consultation with the university's assigned flight training subject matter expert (SME), it was determined that the duplicate records were the result of erroneous latent residual student records that were retained within the MFT database subsequent to routine administrative actions and not observed prior to archiving the data for long-term storage. To resolve the redundant records, a comparison of each line of data within each course and record was completed. Comparison of data focused on quality and completeness of the data within each record. Redundant records with missing data fields within a single course, were removed from the dataset for that course's analysis only. When a redundant record contained a course that matched a removed course record but was complete with data, the complete course record was merged with the original to establish one complete record.

Activity dates. Each dataset record included a dated last activity marker for each course of instruction that was used to determine if the record represented a completed course of instruction. Additionally, the dated last activity marker was used to exclude flight record data recorded on or after March 1, 2020. That data was excluded from analysis in the current study due to unaccounted external variables associated with the (COVID-19 pandemic in early 2020. March 1, 2020 was established as a reasonable data cutoff date to accommodate any unknown performance restrictions or influences that may have affected student performance prior to the Declaration of a State of Emergency that was declared on March 12, 2020 in the region where the host university is located. The Declaration of a State of Emergency, related to the COVID-19 outbreak and subsequent pandemic, necessitated enhanced health screening and cleaning policies and procedures that permitted the host university to continue flight training for several weeks prior to flight operations being ceased at the end of March 2020. However, the introduction of the external variables of enhanced health screening and cleaning, along with the unmeasured psychological and physical stresses associated with continued operations and training in the non-standardized environment, may have influenced or affected student performance and training times and may have adversely affected the findings of this study if any training record with activity dated after March 1, 2020 were included in the analysis of the this study.

Beginning with Commercial Flight I course, there were 37 records identified with a last activity after March 1, 2020. Commercial Flight I is the first course in the commercial and instrument training associated with each degree completion plan (reference Figure I); therefore, each of the subsequent courses (Instrument, Commercial Flight II, and Commercial Flight III) were likewise excluded from any further analysis in the current study. Similarly, for each subsequent course in the course sequence, when it was observed that any training activity occurred after March 1, 2020, each subsequent course in that record was excluded from further analysis. Number of records per course excluded based on last activity date: Commercial I = 37, Instrument = 30, Commercial II = 19, and Commercial III = 38.

Extreme (high / low) values. Next, all records that had no or zero flight hours provided and all records with actual flight hours less than TCO required hours and no subsequent Commercial Flight II course actual flight data were identified. A review of these records indicated that these records could be categorized as records from students who were in the Military Cognate or UAS degree programs and were not required to complete Commercial flight training as a part of their collegiate flight training (Figure 1.1). A second category these records could represent included students who started the Commercial Flight I course, but for various personal reasons decided to change majors to either a non-flying major or a major that did not require commercial flight training (i.e., Military or UAS degrees) and were removed from training prior to conducting any flight activities. Thus, these 65 records were excluded from the study because they represented other paths through flight training.

Records from the transitional period between the legacy flight management software to the flight management software used during the study period contained either unusually high values or missing data fields. A query to the database SME requested additional information regarding the excessively large or absent data fields. In many of the records from the transitional period between database management systems, records from the legacy system were retained in the legacy system and not directly transferred to the new system. In those instances, an administrative note was added to the record stating that the hours required by the TCO in the course were manually entered by the Chief Instructor of the Course and credit for prior training was awarded. As a result of this information, records with courses that were identified as being active during the transitional period of Summer and Fall of 2015 were excluded from the analysis of this study. However, the records were retained for further analysis in subsequent courses if the subsequent courses contained data beginning no earlier than the Spring 2016 semester.

IV Confirmation. As requested, the host university provided the dataset for this study with an indicator of whether each student record contained any type of private pilot training at the university. This data formed the basis for the IV being either collegiate trained private pilot (CTP) or non-collegiate trained private pilot (NCTP). As a result of the current database having been implemented as the university's system of record beginning the Fall of 2015, any student who was actively flying in the university's program prior to that semester did not have any prior training records to identify them as a CTP. In order to identify CTP records with private pilot training contained in the university's pre-MFT database, the flight training SME completed a supplemental, comparative review of both databases and identified 146 records in the MFT database with no recorded private pilot training but had recorded collegiate private pilot training in the pre-MFT database. It was determined and confirmed by the flight records SME that each of those 146 records had been erroneously identified as a NCTP based on the lack of evidence in the MFT database; these records should have been identified as CTP based on evidence observed in the pre-MFT database. Therefore, each of the 146 records identified in this process were recategorized as CTP records for purposes of the current study.

TCO review. Coordination with the flight training SME revealed a 16.1 hour increase in two Commercial Flight II course TCOs' required flight times. The flight training SME identified duplicated line-item entries in two TCOs used in the

Commercial Flight II course. The duplicated line items did not contain any additional RPLs or actual time but did include additional TCO required time that had been included in the dataset. In coordination with the flight training SME, the required flight times for these two Commercial Flight II TCOs were reduced by 16.1 hours, and the updated hours were confirmed against the FAA approved TCO documents. Additionally, a comprehensive review of TCO required times within each course for each DV was accomplished. Any differences noted between the TCO required times in the database and the TCO required times in the TCO documents were confirmed by the flight training SME. Dataset TCO required times were then adjusted to match TCO document required times.

When completing the TCO required time review, it was noted that in the Instrument Flight course, numerous records indicated that the TCO requirements were zero FTD time and a very large number of aircraft hours, roughly equivalent to the total number of ground and flight hours required by the TCO. It was also noted in the same records, inconsistencies in the actual time required for course completion varied widely with many records indicating the course had been completed with an insufficient number of flight hours, as required by the instrument TCO. Furthermore, the last activity date associated with these records was the Fall 2015 semester, the same semester when the university transitioned to MFT. In consultation with the flight training SME, it was revealed these records were used in conjunction with the prior flight management system and administratively updated to record the activity in both flight management systems utilized during the transition semester. Therefore, because the training time data contained within these records could not be accurately identified as either ground or flight time, these 80 records were excluded from analysis in the instrument course.

Additionally, it was noted that several RPL scores were excessively large. In cooperation with the flight training SME, a review of excessively large RPL scores was completed. The review included sampling a minimum of five lessons from the record with the largest RPL score for repeated line items in at least one ground, one FTD, and one flight lesson. This individual record review continued sequentially with the next largest RPL score until five records were sampled with zero line-item RPL errors. A similar review of the lowest summed RPL records was conducted; this review confirmed no issues and no duplicated line items were observed in the low RPL score records. Records found to have repeated line items or missing line items were excluded from analysis in the associated course where the discrepancy was noted. Based on the finding of this review, in each course the number of records excluded from RPL score analysis but retained for amount of time and number of attempts analysis were as follows: Commercial I = 12, Instrument = 0, Commercial II = 6, and Commercial III = 0.

Descriptive Statistics

This section contains a summary of the descriptive statistics related to the student pilot training records accessed during this study. The aggregated summary of the records accessed in this study will provide a review of the data relative to the flight training within a CFR Part 141 regulated, residential collegiate aeronautics flight program that provides ground, simulator, and flight instruction leading to an accredited Bachelor of Science Degree in Aeronautics. The summary will focus on providing descriptive details related to the accessed data relative to the single IV with two group memberships of X_1 = CTP and X_2 = NCTP and sixteen dependent variables (DVs). The IV in the study was the type of private pilot flight training an individual experienced and completed when obtaining a private pilot certificate: CTP or NCTP. Dependent variables were Y_1 = pilot performance in AVIA 325, Commercial Flight I; Y_2 = ground time required to complete AVIA 325, Commercial Flight I; Y_3 = flight time required to complete AVIA 325, Commercial Flight I; Y_4 = pilot performance in AVIA 320, Instrument Flight; Y_5 = ground time required to complete AVIA 320, Instrument Flight; Y_6 = flight time required to complete AVIA 320, Instrument Flight; Y_7 = pilot performance in AVIA 326, Commercial Flight II; Y_8 = ground time required to complete AVIA 326, Commercial Flight II; Y_9 = flight time required to complete AVIA 326, Commercial Flight II; Y_{10} = pilot performance in AVIA 327, Commercial Flight III; Y_{11} = ground time required to complete AVIA 327, Commercial Flight III; Y_{12} = flight time required to complete AVIA 327, Commercial Flight III.

Additional data was provided by the host university that permitted a supplemental analysis of any potential differences between pilot groups in the number of lesson attempts required to complete each semester course. These data included four additional DVs discussed in the Supplemental Analysis section of this Chapter. Additional DVs were Y_{13} = lesson attempts required to complete AVIA 325, Commercial Flight I, Y_{14} = lesson attempts required to complete AVIA 320, Instrument Flight, Y_{15} = lesson attempts required to complete AVIA 326, Commercial Flight II, Y_{16} = lesson attempts required to complete AVIA 327, Commercial Flight III.

In compliance with the approved IRB research guidance from both FIT and the host university, the data set was deidentified prior to use in this study. As such, and because the variables studied within this study were not directly associated with general demographics, such as age and gender, that information was not retained in the deidentified data set provided for use within this study. However, at the time of this writing, host university demographics reflect a residential student population of approximately 15,000 students consisting of 53% female students and 47% male students with a typical undergraduate age of 18 to 24 years of age (Liberty, 2021).

As summarized in Table 4.1, the total number of archived collegiate flight student training records provided by the host university for the current study was 568 (N_{Total} = 568). The data set provided included every collegiate flight student who participated in at least one commercial or instrument flight course between August 2015 and August 2020. Upon receipt of the complete data set, the previously described process for evaluating the validity of the data was completed with the support of the flight records SME. Through the data checking process, 120 flight records from the archived database were identified as not applicable to the current study (i.e., 65 military or UAS, instrument only degree students) or exhibited some type of data validity issue as previously discussed in this chapter and were excluded from use in the current study. Records identified as having activity after March 1, 2020, and subject to the effects of the COVID pandemic, were not excluded from analysis except those courses directly associated with training that may have occurred after March 1, 2020. The final numbers of student records used for analysis are provided in Table 4.1. The sample sizes for all courses were confirmed to be sufficient for the a priori power analysis.

Table 4.1

Summary of Data Records

Pilot Groups[b]	N_{Total}	Flight Course[a] N_{Comm1}	N_{Inst}	N_{Comm2}	N_{Comm3}
All Pilots	412	351	208	274	262
CTP	246	204	132	164	162
NCTP	166	147	76	110	100

Note: N = 568

[a]N_{Total} represents the entire deidentified data set provided by the host university for purposes of this research. N_{Comm1} = all validated flight records for students who participated in and completed the host university's Commercial I flight course. N_{Inst} = all validated flight records for students who participated in and completed the host university's Instrument flight course. N_{Comm2} = all validated flight records for students who participated in and completed the host university's Commercial II flight course. N_{Comm3} = all validated flight records for students who participated in and completed the host university's Commercial III flight course. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Commercial Flight I course pilot performance statistics are provided in Table 4.2. It was noted that the average Commercial Flight I course RPL scores are similar across the CTP and NCTP pilot groups. The standard deviation and range were slightly larger for the NCTP group. Figure 4.1 illustrates the similarity of RPLs across the two groups.

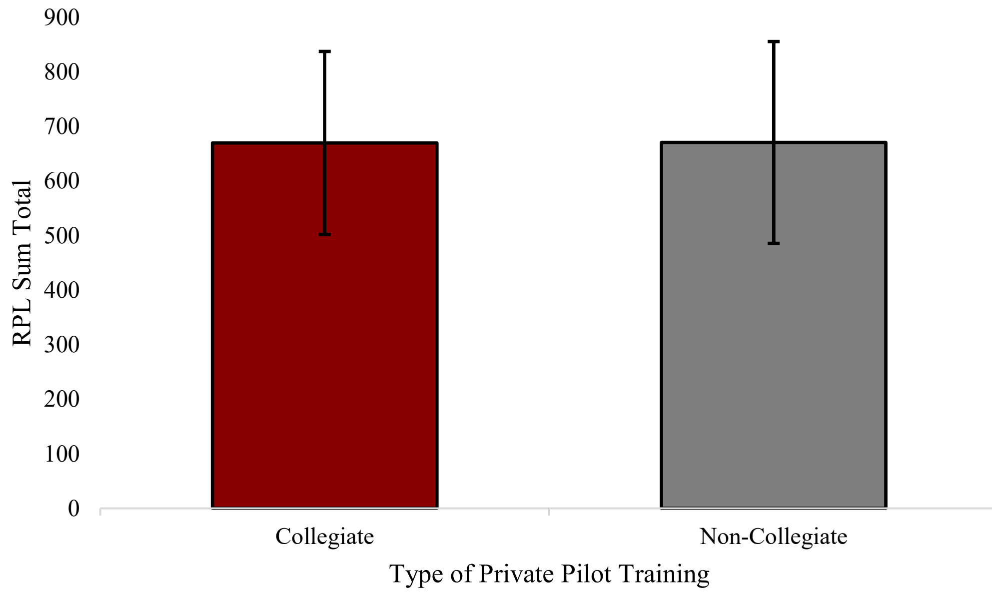
Table 4.2
Commercial Flight I Course Pilot Performance: RPL Scores

		Y_1 = Commercial I Pilot Performance[a]							
Pilot Groups[b]	N_{Comm1}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	337	670	626	645	418	1799	1381	175	9
CTP	193	670	627	645	418	1441	1023	168	12
NCTP	144	671	626	645	431	1799	1368	185	15

Note: N_{Total} = 412

[a] Y_1 represents the Commercial I student pilot performance as measured by the sum total of the CFI assigned RPL scores for every line item in each lesson first attempt within the Commercial Flight I course. N_{Comm1} = all validated flight records for students who participated in and completed the host university's Commercial Flight I course. Lower scores indicate poorer first-time performance. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.1
Commercial Flight I Course Pilot Performance: Mean RPL Score



Note. Comparison of Required Proficiency Level (RPL) sum totals between collegiate-trained and non-collegiate-trained private pilots in the Commercial Flight 1 course. The RPL sum totals depicted in this figure represent the combined sum total of the scored proficiency level from the first attempt of every lesson line item that included and required a minimum RPL for lesson completion. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported RPL sum totals. CTP $N = 193$, NCTP $N = 144$.

Commercial Flight I course ground instruction time statistics are provided in Table 4.3. The reader should take note of the *mean, median*, range, and standard deviation time differences between the CTP and NCTP pilot groups. Specifically, it appears that CTPs required less time, and have a smaller range and standard deviation than NCTPs. The differences between pilot group ground instruction times are further illustrated in Figure 4.2.

Table 4.3

Commercial Flight I Course Ground Instruction Time Required: Standardized

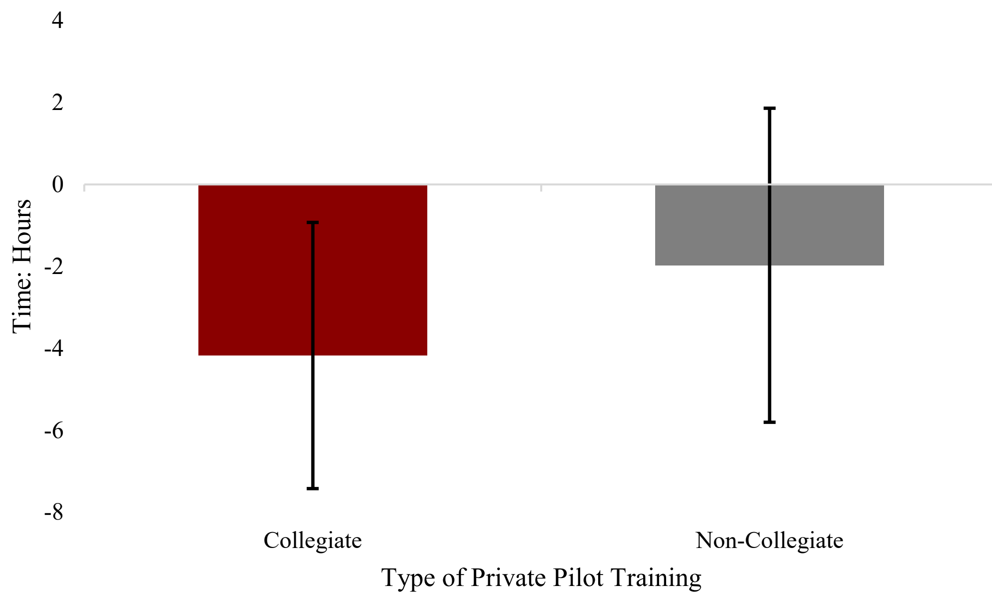
		Y_2 = Commercial Flight I Ground Time[a]							
Pilot Groups[b]	N_{Comm1}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	351	-3.3	-3.7	-4.0	-11.5	9.5	21.0	3.7	0.2
CTP	204	-4.2	-4.4	-4.0	-11.5	8.9	20.4	3.2	0.2
NCTP	147	-2.0	-2.3	-4.5	-9.0	9.5	18.5	3.8	0.3

Note: N_{Total} = 412

[a] Y_2 represents the difference in ground time, to the nearest tenth of an hour, between the amount of ground time spent for successful completion of the Commercial Flight I course and the minimum ground time planned by the TCO. Students requiring more standardized ground time to complete Commercial Flight I, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.2

Commercial Flight I Course Ground Time Required: Standardized Mean



Note. Comparison of ground time required for course completion between CTP and NCTP in the Commercial I Flight course. The number of hours depicted in this figure represent the number of ground instruction hours each student completed, including hours associated with additional and repeated lesson attempts, minus the minimum number of hours required by the TCO. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported instruction time totals. CTP $N = 204$, NCTP $N = 147$.

Commercial Flight I course required flight instruction time statistics are provided in Table 4.4. It should be noted in Table 4.4, there appears to be a slight difference between the mean, median, and range between the CTP and NCTP pilot groups. Specifically, it appears that CTPs required less flight time to complete the Commercial Flight I course but had a wider range of training times when compared to NCTPs.

Table 4.4

Commercial Flight I Course Flight Instruction Time Required: Standardized

		Y_3 = Commercial Flight I Flight Time[a]							
Pilot Groups[b]	N_{Comm1}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	351	0.1	0.2	-0.5	-6.7	7.0	13.7	2.2	0.1
CTP	204	-0.1	0.0	0.0	-6.7	7.0	13.7	2.2	0.2
NCTP	147	0.3	0.3	0.0	-6.7	5.5	12.2	2.2	0.2

Note: N_{Total} = 412

[a]Y_3 represents the difference in flight time, to the nearest tenth of an hour, between the amount of flight time spent for successful completion of the Commercial Flight I course and the minimum flight time planned by the TCO. Students requiring more standardized flight time to complete Commercial Flight I, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

The next sequenced flight course in the host university's Commercial / Corporate Degree Program was the Instrument Flight course (Figure 1.1). Table 4.5 provides pilot performance statistics for the Instrument Flight course. It should be noted in Table 4.5, there appears to be an unexpected difference between the pilot group RPL. Specifically, it appears that the NCTPs had higher RPL scores in the instrument course which indicates better performance when compared to the CTP RPL score. The difference between pilot group RPL scores is illustrated in Figure 4.3.

Table 4.5

Instrument Flight Course Pilot Performance: RPL Scores

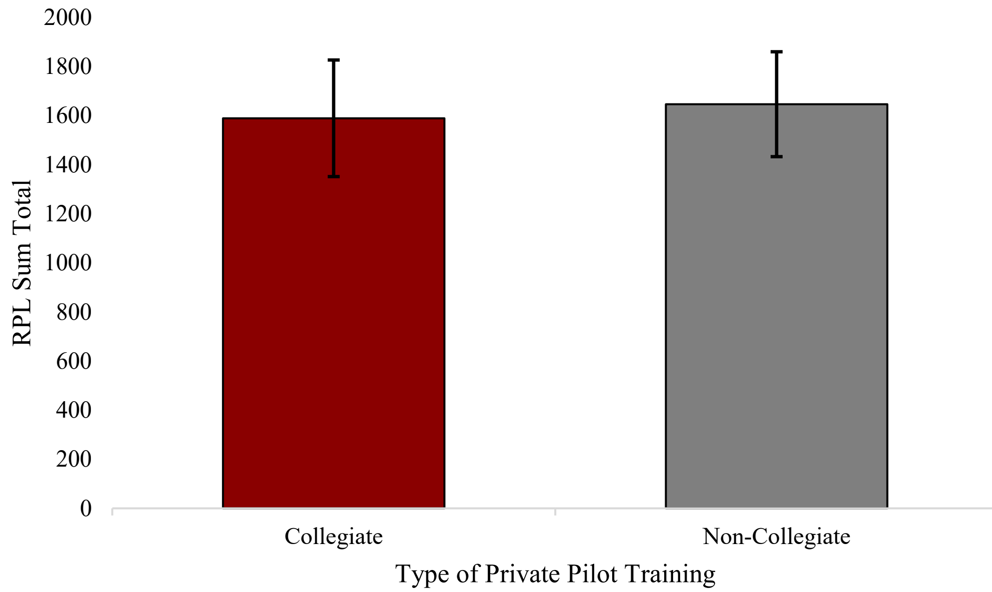
		Y_4 = Instrument Flight Pilot Performance[a]							
Pilot Groups[b]	N_{Inst}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	208	1610	1667	1823	736	2143	1407	230	16
CTP	132	1589	1579	1823	736	2051	1315	237	21
NCTP	76	1646	1727	1527	1244	2143	899	214	25

Note: N_{Total} = 412

[a] Y_4 represents the Instrument course student pilot performance as measured by the sum total of the CFI assigned RPL scores for every line item in each lesson first attempt within the Instrument flight course. N_{Inst} = all validated flight records for students who participated in and completed the host university's Instrument Flight course. Lower scores indicate poorer first-time performance. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.3

Instrument Flight Course Pilot Performance: Mean RPL Score



Note. Comparison of Required Proficiency Level (RPL) sum totals between collegiate-trained and non-collegiate-trained private pilots in the Instrument Flight course. The RPL sum totals depicted in this figure represent the combined sum total of the scored proficiency level from the first attempt of every lesson line item that included and required a minimum RPL for lesson completion. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported RPL sum totals. CTP $N = 132$, NCTP $N = 76$.

Further review of the Instrument Flight course took place through an analysis of ground instruction time. Ground instruction time statistics are provided in Table 4.6. The reader should note in Table 4.6, that there appears to be a difference in ground time required between the pilot groups. Specifically, it appears that CTPs required less time, had a smaller range, and standard deviation than NCTPs. The differences between pilot group ground instruction times are illustrated in Figure 4.4.

Table 4.6

Instrument Flight Course Ground Instruction Time Required: Standardized

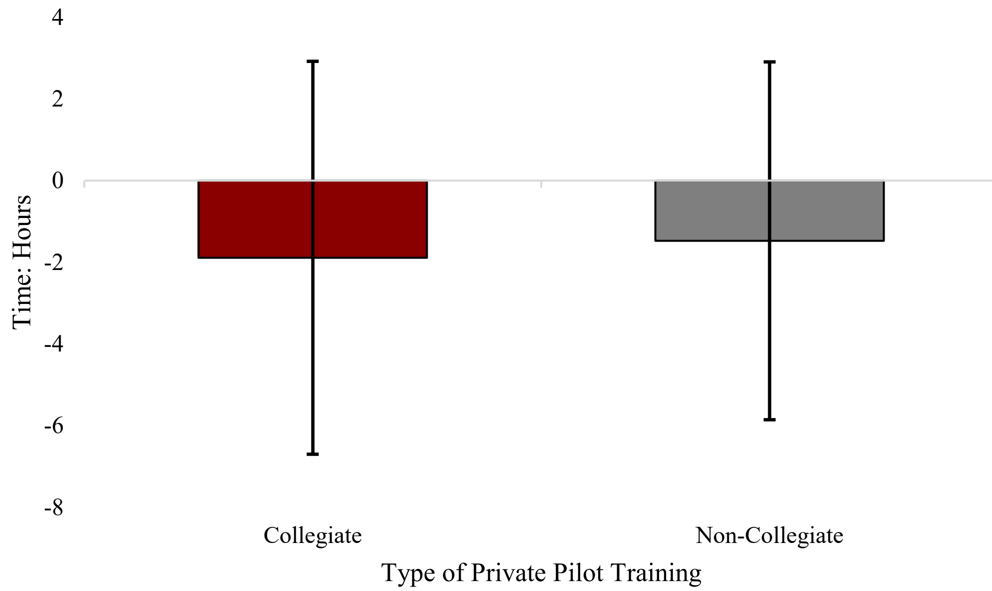
		Y_5 = Instrument Flight Ground Time[a]							
Pilot Groups[b]	N_{Inst}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	208	-1.7	-2.7	-3.5	-11.1	15.8	26.9	4.7	0.3
CTP	132	-1.9	-2.7	-3.5	-11.1	15.8	26.9	4.8	0.4
NCTP	76	-1.5	-2.3	0.3	-10.9	11.1	22.0	4.4	0.5

Note: N_{Total} = 412

[a] Y_5 represents the difference in ground time, to the nearest tenth of an hour, between the amount of ground time spent for successful completion of the Instrument Flight course and the minimum ground time planned by the TCO. Students requiring more standardized ground time to complete the Instrument Flight Course, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.4

Instrument Flight Course Ground Time Required: Standardized Mean



Note. Comparison of ground time required for course completion between CTP and NCTP in the Instrument Flight course. The number of hours depicted in this figure represent the number of ground instruction hours each student completed, including hours associated with additional and repeated lesson attempts, minus the minimum number of hours required by the TCO. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported instruction time totals. CTP $N = 132$, NCTP $N = 76$.

Table 4.7 provides Instrument course flight instruction time statistical information. It should be noted in Table 4.7 that flight time requirements appear to be similar between pilot groups. The similarities between pilot group ground instruction times are illustrated in Figure 4.5.

Table 4.7

Instrument Flight Course Flight Instruction Time Required: Adjusted

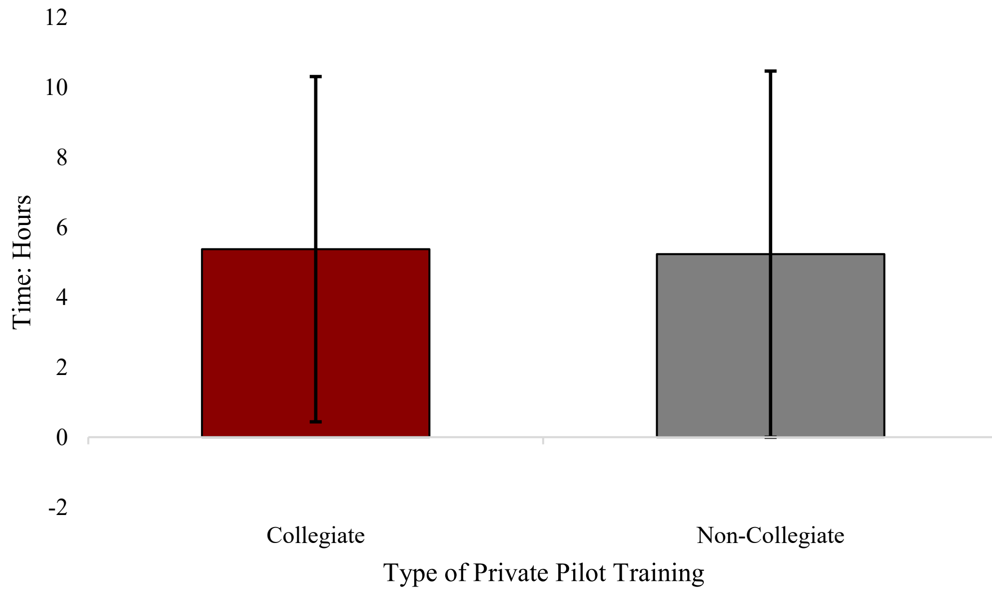
		Y_6 = Instrument Flight Flight Time[a]							
Pilot Groups[b]	N_{Inst}	*M*	*Mdn*	Mode	*Min*	*Max*	*Range*	*SD*	*SE*
All Pilots	208	5.3	4.1	0.7	-1.1	22.2	23.3	5.0	0.3
CTP	132	5.4	4.0	0.0	-1.1	21.6	22.7	4.9	0.4
NCTP	76	5.2	3.9	-0.6	-1.1	22.2	23.3	5.2	0.6

Note: N_{Total} = 412

[a] Y_6 represents the difference in flight time, to the nearest tenth of an hour, between the amount of flight time spent for successful completion of the Instrument course and the minimum flight time planned by the TCO. Students requiring more standardized flight time to complete Instrument Flight, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.5

Instrument Flight Course Flight Time Required: Standardized Mean



Note. Comparison of flight time required for course completion between CTP and NCTP in the Instrument Flight course. The number of hours depicted in this figure represent the number of flight instruction hours each student completed, including hours associated with additional and / or repeated lesson attempts, minus the minimum number of hours required by the TCO. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported instruction time totals. CTP $N = 132$, NCTP $N = 76$

The third of four sequential courses flight students were required to complete was the Commercial Flight II course. Commercial Flight II pilot performance statistical data is provided in Table 4.8. It should be noted that the data in Table 4.8 indicates a difference in RPL mean, median, mode, range, and standard deviation scores existed between CTPs and NCTPs. Understanding that lower RPL scores indicate poorer first attempt performance, it appears that NCTPs performed poorer in their first attempt than CTPs. This relationship is further illustrated in Figure 4.6.

Table 4.8

Commercial Flight II Course Pilot Performance: RPL Scores

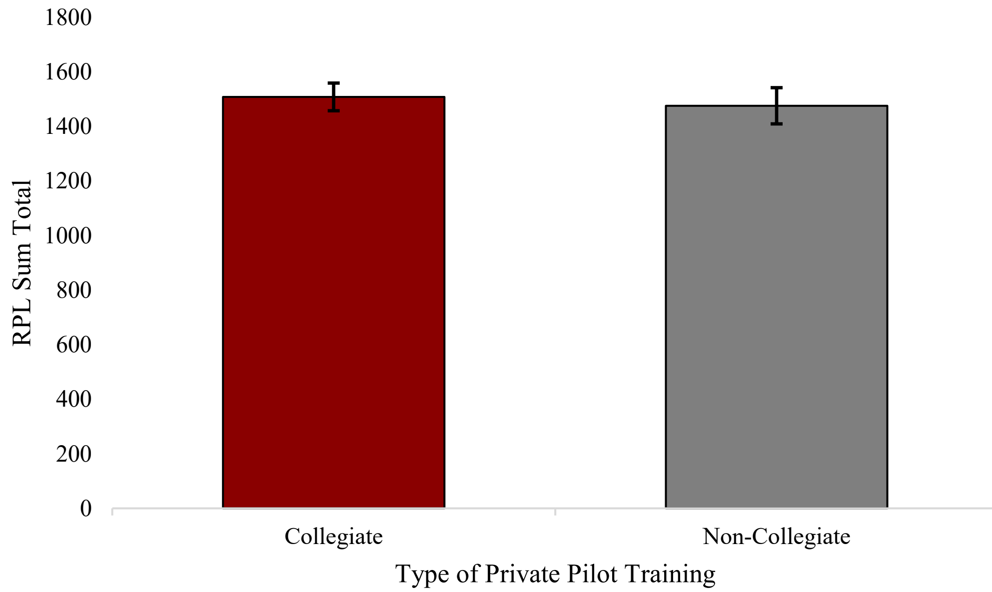
Pilot Groups[b]	N_{Comm2}	Y_7 = Commercial Flight II Pilot Performance[a]							
		M	*Mdn*	Mode	*Min*	*Max*	*Range*	*SD*	*SE*
All Pilots	277	1495	772	3091	256	4619	4363	1082	65
CTP	162	1508	781	748	256	4619	4363	1102	87
NCTP	115	1476	766	772	353	3607	3254	1057	99

Note: N_{Total} = 412

[a] Y_7 represents the Commercial II student pilot performance as measured by the sum total of the CFI assigned RPL scores for every line item in each lesson first attempt within the Commercial Flight II course. N_{Comm1} = all validated flight records for students who participated in and completed the host university's Commercial Flight II course. Lower scores indicate poorer first-time performance. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.6

Commercial Flight II Course Pilot Performance: Mean RPL Score



Note. Comparison of Required Proficiency Level (RPL) sum totals between collegiate-trained and non-collegiate-trained private pilots in the Commercial Flight II course. The RPL sum totals depicted in this figure represent the combined sum total of the scored proficiency level from the first attempt of every lesson line item that included and required a minimum RPL for lesson completion. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported RPL sum totals. CTP $N = 162$, NCTP $N = 115$.

Further review of the Commercial Flight II course took place through an analysis of ground and flight instruction time. Ground instruction time statistics are provided in Table 4.9. It was observed in the Table 4.9 that CTPs and NCTPs required similar standardized ground instruction times when completing the Commercial Flight II course.

Table 4.9

Commercial Flight II Course Ground Instruction Time Required: Standardized

		Y_8 = Commercial Flight II Ground Time[a]							
Pilot Groups[b]	N_{Comm2}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	274	-0.4	-0.6	-1.0	-2.0	2.8	4.8	0.9	0.1
CTP	164	-0.4	-0.6	-1.0	-2.0	2.4	4.4	0.9	0.1
NCTP	110	-0.4	-0.7	-1.0	-2.0	2.8	4.8	1.0	0.1

Note: N_{Total} = 412

[a] Y_8 represents the difference in ground time, to the nearest tenth of an hour, between the amount of ground time spent for successful completion of the Commercial Flight II course and the minimum ground time planned by the TCO. Students requiring more standardized ground time to complete Commercial Flight II, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO.

[b] Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Standardized flight instruction time statistics are provided in Table 4.10. It should be noted that the data in Table 4.10 indicates that CTP and NCTP pilots required similar standardized flight instruction times to complete the Commercial Flight II course.

Table 4.10

Commercial Flight II Course Flight Instruction Time Required: Standardized

		Y_9 = Commercial Flight II Flight Time[a]							
Pilot Groups[b]	N_{Comm2}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	274	2.0	1.8	-1.7	-4.9	12.5	17.4	3.4	0.2
CTP	164	2.0	1.9	-0.5	-4.9	11.0	15.9	3.3	0.3
NCTP	110	2.1	1.6	0.0	-4.7	12.5	17.2	3.6	0.3

Note: N_{Total} = 412

[a] Y_9 represents the difference in flight time, to the nearest tenth of an hour, between the amount of flight time spent for successful completion of the Commercial Flight II course and the minimum flight time planned by the TCO. Students requiring more standardized flight time to complete Commercial Flight II, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

The final commercial flight course required by students was the Commercial Flight III course. Pilot performance descriptive statistics for the Commercial Flight III course are provided in Table 4.11. It should be noted that RPL scores between CTPs and NCTPs in the Commercial Flight III course appear to be similar. This relationship is further illustrated in Figure 4.7.

Table 4.11

Commercial Flight III Course Pilot Performance: RPL Scores

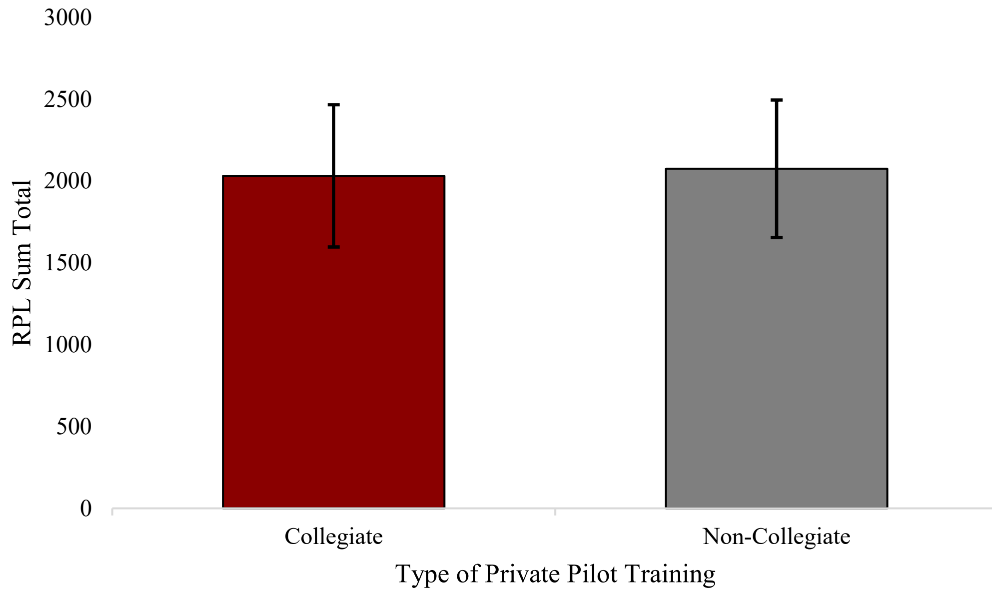
		Y_{10} = Commercial Flight III Pilot Performance[a]							
Pilot Groups[b]	N_{Comm3}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	262	2048	2003	2063	1012	3369	2357	429	28
CTP	162	2031	1996	2084	1044	3369	2325	435	36
NCTP	100	2075	2005	2000	1012	2887	1875	420	44

Note: N_{Total} = 412

[a] Y_{10} represents the Commercial III student pilot performance as measured by the sum total of the CFI assigned RPL scores for every line item in each lesson first attempt within the Commercial Flight III course. N_{Comm1} = all validated flight records for students who participated in and completed the host university's Commercial Flight III course. Lower scores indicate poorer first-time performance. [b]Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.7

Commercial Flight III Course Pilot Performance: Mean RPL Score



Note. Comparison of Required Proficiency Level (RPL) sum totals between collegiate-trained and non-collegiate-trained private pilots in the Commercial Flight III course. The RPL sum totals depicted in this figure represent the combined sum total of the scored proficiency level from the first attempt of every lesson line item that included and required a minimum RPL for lesson completion. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported RPL sum totals. CTP $N = 162$, NCTP $N = 100$.

Further review of the Commercial Flight III course took place through an analysis of ground and flight instruction time. Ground instruction time statistics are provided in Table 4.12. It was observed in the Table 4.12, that ground time required by each pilot group appear to be similar.

Table 4.12
Commercial Flight III Course Ground Instruction Time Required: Adjusted

		Y_{11} = Commercial Flight III Ground Time[a]							
Pilot Groups[b]	N_{Comm3}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	262	2.7	2.0	2.0	-7.9	25.9	33.8	5.8	0.4
CTP	162	2.8	2.0	2.0	-7.1	25.9	33.0	5.8	0.5
NCTP	100	2.4	1.8	2.0	-7.9	25.6	33.5	5.8	0.6

Note: N_{Total} = 412
[a] Y_{11} represents the difference in ground time, to the nearest tenth of an hour, between the amount of ground time spent for successful completion of the Commercial Flight III course and the minimum ground time planned by the TCO. Students requiring more standardized ground time to complete Commercial Flight III, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO.
[b] Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Commercial Flight III flight instruction time statistics are provided in Table 4.13. It was noted in Figure 4.13 that NCTPs had a lower required flight instruction time mean, median, range, and standard deviation than CTPs in Commercial Flight III course. These findings are further illustrated in Figure 4.8.

Table 4.13
Commercial Flight III Course Flight Instruction Time Required: Standardized

		Y_{12} = Commercial Flight III Flight Time[a]							
Pilot Groups[b]	N_{Comm3}	*M*	*Mdn*	Mode	*Min*	*Max*	Range	*SD*	*SE*
All Pilots	262	2.6	1.8	1.3	-7.1	19.4	26.5	4.8	0.3
CTP	162	3.1	2.4	1.2	-7.0	19.4	26.4	5.2	0.4
NCTP	100	1.7	1.3	0.7	-7.1	15.4	22.5	4.0	0.3

Note: N_{Total} = 412

[a] Y_{12} represents the difference in flight time, to the nearest tenth of an hour, between the amount of flight time spent for successful completion of the Commercial Flight III course and the minimum flight time planned by the TCO. Students requiring more standardized flight time to complete Commercial Flight III, demonstrated poorer performance. Within each course, negative standardized times are acceptable. The minimum amount of time required by each TCO was required to have been met prior to completion of all courses supporting each TCO.
[b] Collegiate Trained Pilots (CTP / X_1) = Collegiate flight students who obtained a private pilot certificate from collegiate flight program. Non-Collegiate Trained Pilots (NCTP / X_2) = Collegiate flight students who obtained a private pilot certificate from a non-collegiate flight training program.

Figure 4.8

Commercial Flight III Course Flight Time Required: Standardized Mean

Note. Comparison of flight time required for course completion between CTP and NCTP in the Commercial Flight III course. The number of hours depicted in this figure represent the number of flight instruction hours each student completed, including hours associated with additional and repeated lesson attempts, minus the minimum number of hours required by the TCO. The error bar for each IV group (Collegiate and Non-collegiate) represents the *SD* of reported instruction time totals. CTP $N = 162$, NCTP $N = 100$.

Inferential Statistics

Overview. The primary purpose of the current study was to evaluate the effect of the type of private pilot training, either CTP or NCTP, had on subsequent student pilot performance and the time required to complete residential collegiate commercial and instrument flight training courses. To facilitate more timely results and potential findings associated with the purpose of this study, an ex post facto, effects-based research methodology and design was best suited to address the research questions. Timeliness of study results and potential findings was accelerated with the use of archived flight training data spanning an approximate five-year period. Within the deidentified dataset, IV group membership was identified as CTPs and NCTPs. Three inferential statistical procedures were employed in the current study. For the analysis of the cumulative RPL mean scores within each course, an independent-samples *t* test was most appropriate in order to compare two, non-overlapping group means. For the analysis of the standardized ground and flight training times within each course, a MANOVA with univariate follow-up analyses was most appropriate in order to compare any differences between the means of two groups (i.e., two types of private pilot instruction, CTP and NCTP) across a single flight course. In the supplemental analysis of the standardized training attempts within each course, a Mann-Whitney U test was considered most appropriate to compare the number of attempts between two groups in data with a nonparametric distribution.

Preliminary analysis. Prior to conducting the independent-samples *t* tests, MANOVAs, and Mann-Whitney U tests, preliminary analyses were completed to clean the dataset of any outliers and missing data. The dataset was then checked against the independent-samples *t* test, MANOVA, and Mann-Whitney U test assumptions. The following section outlines the steps taken to establish and prepare the dataset for the testing.

Missing Data. As a part of the initial review of the dataset previously described in this chapter, records from the Fall of 2015 MFT transition period were identified as missing data. The flight training SME determined that the missing data was the result of Chief Instructor administrative actions for students who were actively participating in a flight course training during the period when the MFT data management system was activated. It was noted in student records from that period that these students had been awarded ground and flight time credit for recorded flight training activities in the legacy data management system, but lesson RPLs had not been transferred to MFT. Therefore, those records were retained for time related data analysis but excluded from pilot performance analysis.

Outlier analysis. Outliers are data that exhibit very high or very low scores and may represent either contaminated data or rare cases. Contaminated data can occur when data have been entered incorrectly or are the result of an error. Rare cases can occur if records exhibit an abnormally high or low level of experience or expertise relative to other flight students. In the current study, records exhibiting abnormally high or low values were identified and resolved in the data validity check. To check the dataset for outliers, SPSS was used to calculate a *z*-score for each datum within each DV. *Z*-scores are standardized scores that represent the standard deviation relationship of the datum to the mean of the data being standardized. Course records with data that contained a *z*-score equal to or greater than, or equal to or less than 3.0 were excluded. As expected, due to established FAA TCO minima, it was observed that all of the outliers identified by this method occurred above the data means. Further analysis of outlier causation was restricted because the dataset contained deidentified data derived from an archived database. Course records excluded from analysis as outliers included 8 Commercial Flight I, 7 Instrument Flight, 10 Commercial Flight II, and 14 Commercial III records.

Assumptions for independent-samples* t *test. Additional assumptions are required for statistical tests. For independent-samples *t* tests, the following assumptions must be met: (a) independence of observations, (b) the IV is categorical with two groups, (c) a continuous DV, (d) an approximately normally distributed DV for each IV group, and (e) homogeneity of variances. Compliance with each assumption is discussed in the following sections.

Independence. The independence assumption seeks to ensure that each DV observation is independent of all other observations. The data was stored in a secure database with personally identifiable information required by the FAA for flight training record keeping. Prior to the dataset being released for use in this study, personally identifiable data was removed, and an individual record number was assigned to each record. Based on the record keeping requirements associated with the database, the independence assumption was met; each record was for the flight records of a unique student pilot training at the host university.

Categorical IV. The categorical IV assumption ensures a distinction between IV groups when analyzing each DV to determine the presence of any effects. The IV in this study was the type of private pilot flight training an individual experienced and completed when obtaining a private pilot certificate.

For the purposes of this study, group membership was established as either CTP or NCTP. Prior to deidentification of the dataset, the database SME conducted a data search of each flight training record for evidence of completed private pilot training at the host university. Student flight records in the MFT and legacy ETA data management systems were accessed as a part of the search. Students with no host university record of completing residential collegiate private pilot training were categorized as NCTP. The NCTP group membership was then cross referenced by the flight training SME against the results of a student questionnaire previously conducted by the host university which provided student derived responses to prior flight training experiences (see also Validity Checking*: IV Confirmation*).

Continuous DV. The continuous DV assumption is concerned with the measurement of the DV values on a continuous level. The RPL scores are the summation of individually graded TCO line items for each lesson in a flight course and are measured on a continuous scale.

Approximately normal distributions of DVs. The normal distribution assumption is concerned with the normal distribution of data. To test this assumption, the Shapiro-Wilk test for normality was conducted. All four of the RPL DVs did not meet the test threshold for a normal distribution. This was to be expected as a result of each DV dataset being greater than 200 records. Field (2018) and Gallo (2018) both noted that when a sample size is sufficiently large, the Shapiro-Wilk test may detect even trivial departures from the null hypothesis. For larger datasets, reliance on the Central Limit Theorem and visual interpretation of Q-Q plots and histograms was recommended to determine normal or approximately normal distributions in datasets. Therefore, a visual inspection of the Q-Q plots and histograms, with a normal distribution curve superimposed, for each DV was conducted. It was determined that each of the DVs appeared to represent an approximately normal distribution of data.

Homogeneity of variances. This assumption is concerned with measuring variances across residual values regardless of the IV values. To test this assumption, the Levene's test of equality of error variances was conducted. Results of the Levene's test indicate that the assumption of homogeneity of variances was met in all the RPL related DVs: Commercial I (p = .94), Instrument (p = .19), Commercial II (p = .63), Commercial III (p = .83).

Assumptions for MANOVA. For a MANOVA, the following assumptions must be met: (a) independence of observations, (b) the IV is categorical with two groups, (c) linear relationships between DV pairs, (d) homogeneity of variances, and (e) approximately normal distributions of DVs. Compliance with each assumption is discussed in the following sections.

Independence. As previously described in the assumptions for independent-samples *t* test section, all records meet the assumptions for independence.

Categorical IV. As previously described in the assumptions for independent-samples *t* test section, this assumption was met with the IV being the category of type of private pilot flight training experienced by the study's population and the student time-used DVs having been measured continuously against TCO required time.

Multicollinearity. An assumption with multivariate analysis is that each variable has the potential to provide a unique contribution to the observed variance. To ensure this, variables must not be highly correlated. Bivariate correlation analyses between DVs were conducted using SPSS to assess DV relationships. Correlation coefficients of $r > .8$ are considered problematic for a MANOVA. Within each course, the highest correlation coefficient between DVs was $r = .46$. Therefore, it was determined multicollinearity was not an issue.

Linearity. The linearity assumption is concerned with the shape or form of the relationship between DVs. To test this assumption, a scatterplot matrix was produced for each DV pair split between the IV group memberships. Visual interpretation of each scatterplot indicated that although the linear relationship between variables was not well defined, there was sufficient visual linearity shape and form to indicate a general linear trend between each pair of DVs within each course.

Continuous DV. The continuous DV assumption is concerned with the measurement of DV values on a continuous level. Lesson time DVs used in the current study are measured on a continuous scale.

Approximately normal distributions of DVs. For a MANOVA, the normal distribution assumption is concerned with the normal distribution of data across the DVs. However, to test this assumption for a MANOVA, the Shapiro-Wilk test for normality is performed on each univariate DV within the MANOVA. To test this assumption, the Shapiro-Wilk test for normality was conducted on each DV. All of the time related DVs did not meet the threshold for a normal distribution except Commercial Flight I course flight time. This was to be expected as a result of each DV dataset being greater than 200 records. Field (2018) and Gallo (2018) both noted that when a sample size is sufficiently large, the Shapiro-Wilk test may detect even trivial departures from the null hypothesis. For larger datasets, reliance on the Central Limit Theorem and visual interpretation of Q-Q plots and histograms to determine normal or approximately normal distributions in datasets was recommended (Field, 2018; Gallo, 2018). A visual inspection of the Q-Q plots and histograms, with a normal distribution curve superimposed, for each DV was conducted. It was determined that each of the DVs appeared to represent an approximately normal distribution of data.

Homogeneity of variances. This assumption is concerned with measuring variances across residual values regardless of the IV values. To test this assumption, the Levene's test of equality of error variances was conducted. Results of the Levene's test indicate that the assumption of homogeneity of variances was met in the all the DVs except Commercial Flight I ground time, and Commercial

Flight III flight time. However, Field (2018, p. 397) noted that "…the *F*-statistic can be adjusted to correct for the degree of heterogeneity." Field (2018) further recommends that when the homogeneity of variances is not met in unequal groups sizes, the Welch's *F* test may be used as the follow-on univariate statistical test. Therefore, although two of the DVs did not comply with the homogeneity of variances assumption, these findings did not preclude continuation of the primary analysis. The Welch's test was used to correct for a statistically significant Levene's test of homogeneity of variances in the Commercial Flight I course ground time follow-on one-way ANOVA and the Commercial Flight III course flight time.

Assumptions for Mann-Whitney U tests. For Mann-Whitney U tests, the following assumptions must be met: (a) independence of observations, (b) the IV is categorical with two groups, (c) a continuous or ordinal DV, and (d) both of the DV group distributions are the same shape. Compliance with each assumption is discussed in the following sections.

Independence. As previously described in the assumptions for independent-samples *t* test section, the independence assumption was met.

Categorical IV. As previously described in the assumptions for independent-samples *t* test section. The categorical IV assumption was met.

Continuous DV. The continuous DV assumption is concerned with the measurement of the DV values on a continuous level. Lesson attempt DVs used in the current study are measured on a continuous scale.

Shape of DV group distributions. The shape of DV group distributions is concerned with determining the shape of the distribution of data. Data that has the same shape permits comparison of medians and mean ranks. However, if the DV group distributions are not similarly shaped, the Mann-Whitney U test can only be used to compare mean ranks. To determine the shape of each DV group distribution, a visual inspection of the data using histograms was conducted. All of the DV groups distributions were positively skewed and have approximately same shape.

Primary analysis 1: Comparison of student performance (RPLs) by pilot group in each flight course. To examine the effect of the type of private pilot training on subsequent commercial and instrument pilot training performance, an independent-samples *t* test was utilized for each commercial and instrument course.

Commercial Flight I. An independent-samples *t* test was run to determine if there were differences in pilot performance in the Commercial Flight I course between CTPs and NCTPs. There were 193 CTPs and 144 NCTPs. There was no statistically significant difference in pilot performance in the Commercial Flight I course between CTPs (M = 670, SD = 168) and NCTPs (M = 671, SD = 185), 95%

CI [-39, 37], $t(335) = -.05$, $p = .96$. Cohen's d was less than .01, which is considered to be a negligible effect size.

Instrument Flight. An independent-samples t test was run to determine if there were differences in pilot performance in the Instrument Flight course between CTPs and NCTPs. There were 132 CTPs and 76 NCTPs. There was no statistically significant difference in pilot performance in the Instrument Flight course between CTPs ($M = 1589$, $SD = 237$) and NCTPs ($M = 1646$, $SD = 214$), 95% CI [-122, 8], $t(206) = 1.71$, $p = .08$. Cohen's d was .25, which is considered to be a small effect.

Commercial Flight II. An independent-samples t test was run to determine if there were differences in pilot performance in the Commercial Flight II course between CTPs and NCTPs. There were 162 CTPs and 115 NCTPs. There was no statistically significant difference in Commercial Flight II course pilot performance between CTPs ($M = 1508$, $SD = 1102$) and NCTPs ($M = 1476$, $SD = 1057$), 95% CI [-228, 293], $t(275) = .24$, $p = .81$. Cohen's d was .03, which is considered to be little to no effect.

Commercial Flight III. An independent-samples t test was run to determine if there were differences in pilot performance in the Commercial Flight III course between CTPs and NCTPs. There were 162 CTPs and 100 NCTPs. There was no statistically significant difference in pilot performance in the Commercial Flight III course between CTPs ($M = 2031$, $SD = 435$) and NCTPs ($M = 2075$, $SD =$

420), CI [-156, 69], $t(236) = .05$, $p = .45$. Cohen's d was .10, which is considered to be a small effect.

Primary analysis 2: Comparison of ground and flight training times by pilot group for each flight course. A one-way MANOVA was run to examine the effect of the type of private pilot training on subsequent commercial and instrument pilot training time required for each commercial and instrument course.

Commercial Flight I. CTPs required less time (fewer hours) to complete the required Commercial Flight I course ground ($M = -4.2$, $SD = 3.2$) and flight training requirements ($M = -.1$, $SD = 2.2$) than NCTPs ($M = -2.0$, $SD = 3.8$, and $M = .3$, $SD = 2.3$, respectively). The MANOVA indicated a statistically significant difference between CTPs and NCTPs, $F(2, 348) = 16.8$, $p < .001$; Wilks' $\Lambda = .91$; partial $\eta^2 = .09$. A follow-up univariate Welch's ANOVA revealed that ground instruction time ($F(1, 282) = 32.0$, $p < .001$; $d = .63$) had a statistically significant difference between CTPs and NCTPs, using a Bonferroni adjusted α level of .025. Cohen's $d = .63$ represents a medium to large effect size. Furthermore, the follow-up univariate ANOVA for flight instruction time showed no statistically significant difference between CTPs and NCTPs ($F(1, 349) = 2.5$, $p = .12$; $d = .17$). MANOVA observed statistical power was greater than .999. Follow-up univariate ANOVAs observed statistical power presented in Table 4.14.

Instrument Flight. The MANOVA revealed no significant differences between CTPs and NCTPs, $F(2, 205) = .3$, $p = .72$; Wilks' $\Lambda > .99$; partial $\eta^2 < .01$.

MANOVA observed statistical power was .10. Although the MANOVA was insignificant, underlying univariate ANOVA results are presented in Table 4.14 for the benefit of the reader.

Commercial Flight II. The MANOVA revealed no significant differences between CTPs and NCTPs with, $F(2, 271) < .1$, $p = .96$; Wilks' $\Lambda > .99$; partial $\eta^2 < .01$. MANOVA observed statistical power was .06. Although the MANOVA was insignificant, underlying univariate ANOVA results are presented in Table 4.14 for the benefit of the reader.

Commercial Flight III. The MANOVA revealed insignificant differences between CTPs and NCTPs, $F(2, 259) = 2.6$, $p = .08$; Wilks' $\Lambda = .98$; partial $\eta^2 = .02$. MANOVA observed statistical power was .51. Although the MANOVA was insignificant, underlying univariate ANOVA results are presented in Table 4.14 for the benefit of the reader.

Main effects. The follow up univariate analysis is presented in Table 4.14. It was noted that there was a statistically significant difference in the Commercial Flight I ground instruction time between the CTP and NCTP student training records, $F(1, 349) = 33.8$, $p < .01$; partial $\eta^2 = .09$. Type of private pilot training did not have a statistically significant effect on any of the other RPL or time related DVs. In the context of the current study, student pilots, who obtained a private pilot certificate from a residential collegiate flight program, required fewer hours of ground instruction time in the initial phase of commercial flight training. The practical significance of these findings is discussed in Chapter 5.

Table 4.14

One-way MANOVA Univariate Follow-up Analyses: Summary of Type of Private Pilot Training Effect on Ground Time and Flight Time by Flight Course

Type of instruction time	Test Results				
	F	*df*	*p*	*d*	$1 - \beta^a$
Commercial Flight I					
Ground Time[b]	32.0	1, 282	< .001*	.63	>.999
Flight Time	2.5	1, 349	.12	.17	0.36
Instrument Flight					
Ground Time	.4	1, 206	.54	.09	.10
Flight Time	< .1	1, 206	.85	.03	.05
Commercial Flight II					
Ground Time	< .1	1, 272	.91	.01	.05
Flight Time	.1	1, 272	.77	.04	.06
Commercial Flight III					
Ground Time	.3	1, 260	.60	.07	.08
Flight Time[b]	5.7	1, 247	.02[c]	.29	.61

Note: $N_{Total} = 412$
[a]Observed. [b]Welch's ANOVA results provided due to Levene's test $p < .05$. [c]Insignificant based on non-directional (two-tailed) test ($p = .05 / 2 = .025$) and Bonferroni adjusted α level of .013. *NTotal* represents the entire deidentified data set provided by the host university for purposes of this research.
*$p < .025$. Statistically significant α based on using a Bonferroni adjusted α level of .025.

Supplemental Analysis:

The following section presents an analysis of an additional measurement in determining the effect of type of private pilot training on subsequent commercial and instrument flight training. The question explored in the supplemental analysis was: What was the difference in number of lesson attempts required in commercial and instrument flight courses between students who obtained a private pilot certificate from a residential collegiate program compared to students who obtained a private pilot certificate from a non-collegiate program?

The null hypothesis was that there will be no statistical difference in commercial pilot certification and instrument rating completion lesson attempts between students who obtained a private pilot certificate from a residential collegiate program and students who obtained a private pilot certificate from a non-collegiate program. The research hypothesis were that students who obtained a private pilot certificate from a non-collegiate program will require more lessons in the Commercial Flight I and Instrument Flight Course; and the same number of lessons in Commercial Flight II and III courses to obtain a commercial pilot certificate and instrument rating in residential collegiate commercial and instrument pilot training compared to students who obtained a private pilot certificate from a residential collegiate program.

Data used for the supplemental analysis was provided at the same time and in the same format as the other deidentified student flight training records.

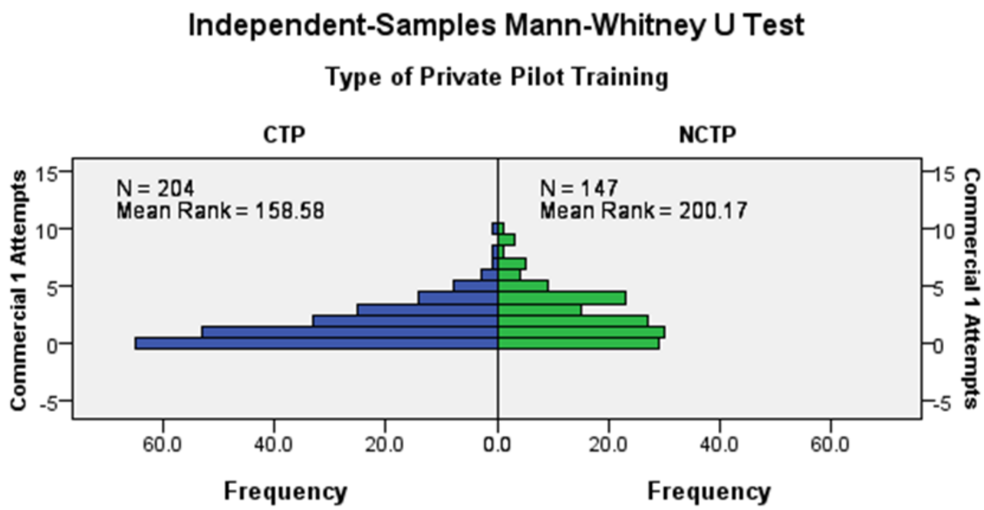
Management and handling of the data was coincident with previously described procedures in this chapter. Upon visual inspection of the lesson attempts data for compliance with the normal distribution assumption required to perform an independent-samples *t* test, the data appeared to be positively skewed and does not approximate a normal distribution of data. Therefore, a non-parametric Mann-Whitney U statistical test was selected as the primary statistical test for conducting a supplemental analysis of the effect of type of private pilot training on student lesson attempts in commercial and instrument flight training. The Mann-Whitney U test was considered the most appropriate test because it is similar to the independent-samples *t* test but does not assume normality of data.

Supplemental analysis 1: Analysis of lessons required by pilot group for each flight course. Due to the positively skewed non-parametric distribution of the lesson attempt DV, a Mann-Whitney U test was used to determine if there were differences in course lesson attempts between CTPs and NCTPs. This analysis was conducted in addition to the primary analyses.

Commercial Flight I. CTPs required significantly fewer lessons to complete the Commercial Flight I course (Mdn = 1) than NCTPs (Mdn = 2). The Mann-Whitney U test indicated a statistically significant difference between CTPs and NCTPs, U = 11,441, z = -3.87, $p < .001$. Distributions of lesson attempts for CTPs and NCTPs were similar (Figure 4.9).

Figure 4.9

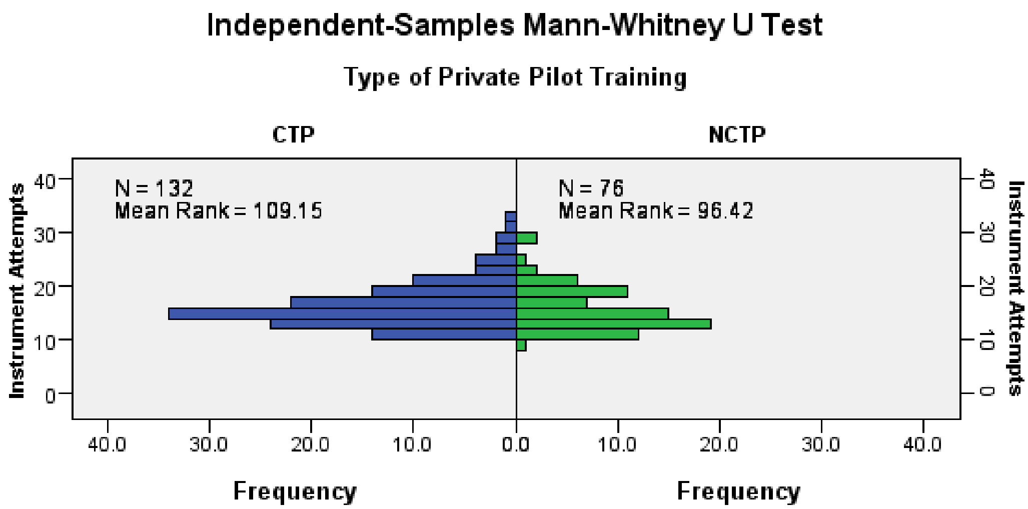
Commercial Flight I Course Lesson Attempts Required: Standardized Median



Note. Comparison of lesson attempts required for course completion between CTP and NCTP in the Commercial Flight I course. The number of lessons depicted in this figure represent the number of ground and flight lessons each student completed, including additional and / or repeated lesson attempts, minus the minimum number of lessons identified in the applicable TCO.

Instrument Flight. CTPs (*Mdn* = 15) and NCTPs (*Mdn* = 14) required an approximately equivalent number of lessons to complete the Instrument Flight course ground. The Mann-Whitney U test indicated no significant difference between CTPs and NCTPs, *U* = 5,630, *z* = 1.48, *p* = .14. Distributions of lesson attempts for CTPs and NCTPs were similar (Figure 4.10).

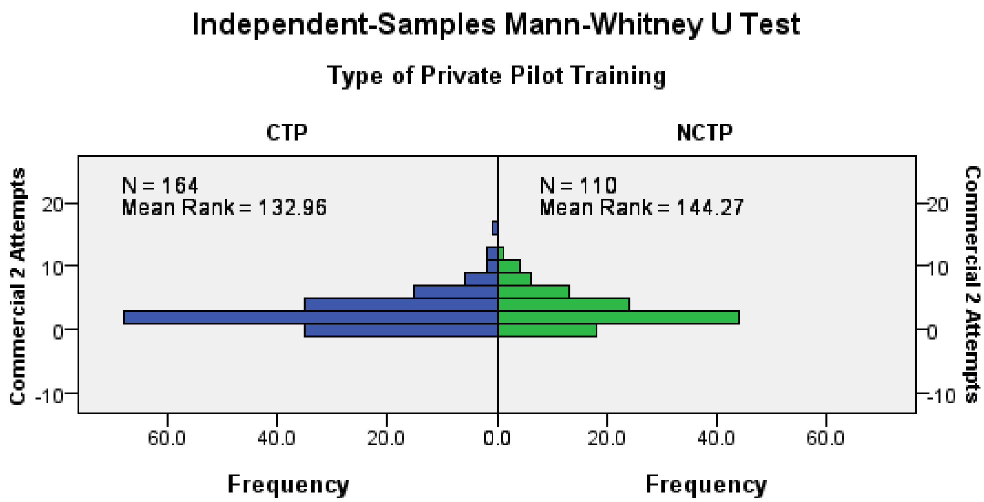
Figure 4.10
Instrument Flight Course Lesson Attempts Required: Standardized Median



Note. Comparison of lesson attempts required for course completion between CTP and NCTP in the Instrument Flight course. The number of lesson depicted in this figure represent the number of ground and flight lessons each student completed, including additional and / or repeated lesson attempts, minus the minimum number of lessons identified in the applicable TCO.

Commercial Flight II. CTPs (*Mdn* = 2) required the same number of lessons to complete the Commercial Flight II course ground as NCTPs (*Mdn* = 2). The Mann-Whitney U test indicated no significant difference between CTPs and NCTPs, $U = 8{,}275$, $z = -1.17$, $p = .24$. Distributions of lesson attempts for CTPs and NCTPs were similar (Figure 4.11).

Figure 4.11
Commercial Flight II Course Lesson Attempts Required: Standardized Median

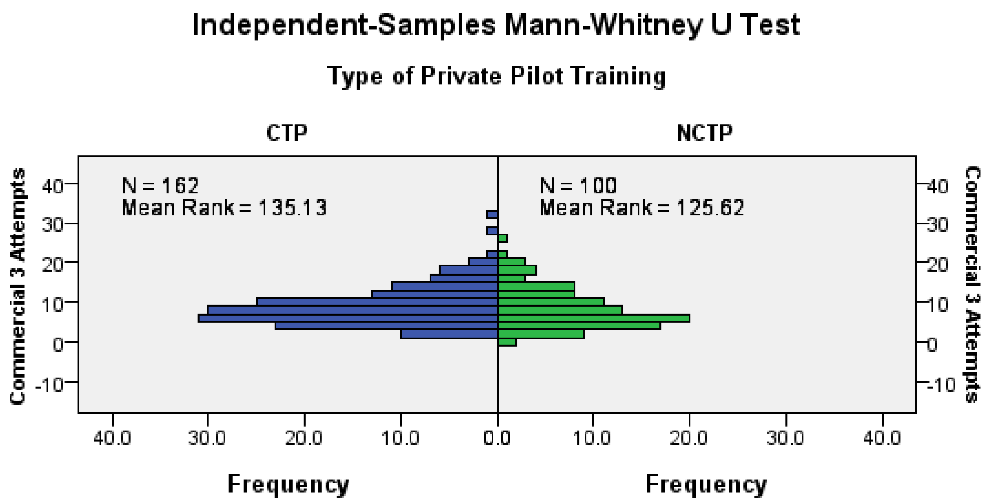


Note. Comparison of lesson attempts required for course completion between CTP and NCTP in the Commercial Flight II course. The number of lesson depicted in this figure represent the number of ground and flight lessons each student completed, including additional and / or repeated lesson attempts, minus the minimum number of lessons identified in the applicable TCO.

Commercial Flight III. CTPs (*Mdn* = 8) and NCTPs (*Mdn* = 7) required a similar number of lessons to complete the Commercial Flight III course ground. The Mann-Whitney U test indicated no significant difference between CTPs and NCTPs, $U = 8{,}687$, $z = .99$, $p = .32$. Distributions of lesson attempts for CTPs and NCTPs were similar (Figure 4.12).

Figure 4.12

Commercial Flight III Course Lesson Attempts Required: Standardized Median



Note. Comparison of lesson attempts required for course completion between CTP and NCTP in the Commercial Flight III course. The number of lesson depicted in this figure represent the number of ground and flight lessons each student completed, including additional and / or repeated lesson attempts, minus the minimum number of lessons identified in the applicable TCO.

Results of Hypotheses Testing

Null hypothesis 1a: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate the same level of flight training performance in the first third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The independent-samples t test on Commercial Flight I course RPL scores revealed no significant difference between CTP and NCTP pilot performance (CTP (M = 670, SD = 168), NCTP (M = 671, SD = 185), 95% CI [-39, 37], $t(335) = -.05$, $p = .96$). This insignificant finding between CTP and NCTP groups indicates each group performed equally as well on the initial attempt of each flight lesson in the Commercial Flight I course. Therefore, the null hypothesis was accepted.

Null hypothesis 1b: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate the same level of flight training performance in instrument pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The independent-samples *t* test on Instrument Flight course RPL scores revealed no significant differences between CTP and NCTP pilot performance (CTP (M = 1589, SD = 237), NCTP (M = 1646, SD = 214), 95% CI [-122, 8], $t(206) = 1.71$, $p = .08$). There was no difference in performance measured between the two pilot groups. Therefore, the null hypothesis was accepted.

Null hypothesis 1c: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate the same level of flight training performance in the second third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The independent-samples *t* test on Commercial Flight II course RPL scores revealed no significant difference between CTP and NCTP pilot performance (CTP (M = 1508, SD = 1102), NCTP (M = 1476, SD = 1057), 95% CI [-228, 293], $t(275) = .24$, $p = .81$). There was no difference in performance measured between the two pilot groups. Therefore, the null hypothesis was accepted.

Null hypothesis 1d: Students who obtained a private pilot certificate from a non-collegiate program will demonstrate the same level of flight training performance in the final third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The independent-samples *t* test on Commercial Flight III course RPL scores revealed no significant difference between CTP and NCTP pilot performance (CTP (M = 2031, SD = 435), NCTP (M = 2075, SD = 420), CI [-156, 69], $t(236) = .05$, $p = .45$). There was no difference in performance measured between the two pilot groups. Therefore, the null hypothesis was accepted.

Null hypothesis 2a: Students who obtained a private pilot certificate from a non-collegiate program will require the same amount of time in the first third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The MANOVA of the Commercial Flight I course identified a statistically significant difference between CTPs and NCTPs on the ground and flight time DVs, $F(2, 348) = 16.8$, $p < .001$; Wilks' $\Lambda = .91$; partial $\eta^2 = .09$. Follow-up univariate ANOVAs identified a statistically significant difference between pilot groups in ground instruction time (Table 4.14). There was no significant difference between CTPs and NCTPs in flight time during the Commercial Flight I course (Table 4.14). These findings indicate that NCTPs required more ground instruction time than CTPs to complete the Commercial Flight I course. Therefore, the null hypothesis was rejected.

Null hypothesis 2b: Students who obtained a private pilot certificate from a non-collegiate program will require the same amount of time in the instrument pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The MANOVA of the Instrument Flight course ground and flight time DVs identified no statistically significant difference between CTPs and NCTPs, $F(2, 205) = .3$, $p = .72$; Wilks' $\Lambda > .99$; partial $\eta^2 < .01$. Follow-up univariate ANOVAs identified no significant difference between CTPs and NCTPs in either ground or flight time during the Instrument Flight course (Table 4.14). Therefore, the null hypothesis was accepted.

Null hypothesis 2c: Students who obtained a private pilot certificate from a non-collegiate program will require the same amount of time in the second third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The MANOVA of the Commercial Flight II course ground and flight time DVs identified no statistically significant difference between CTPs and NCTPs, $F(2, 271) < .1$, $p = .96$; Wilks' $\Lambda > .99$; partial $\eta^2 < .01$. Follow-up univariate ANOVAs identified no significant difference between CTPs and NCTPs in either ground or flight time during the Commercial Flight II course (Table 4.14). Therefore, the null hypothesis was accepted.

Null hypothesis 2d: Students who obtained a private pilot certificate from a non-collegiate program will require the same amount of time in the final third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The MANOVA of the Commercial Flight III course ground and flight time DVs identified no statistically significant difference between CTPs and NCTPs, $F(2, 259) = 2.6$, $p = .08$; Wilks' $\Lambda = .98$; partial $\eta^2 = .02$. Follow-up univariate ANOVAs identified no significant difference between CTPs and NCTPs in either ground or flight time during the Commercial Flight III course (Table 4.14). Therefore, the null hypothesis was accepted.

Supplemental null hypothesis S1a: Students who obtained a private pilot certificate from a non-collegiate program will require the same number of lessons attempts in the first third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The Mann-Whitney U test of the Commercial Flight I course lesson attempts identified a statistically significant difference between CTPs (*Mdn* = 1) and NCTPs (*Mdn* = 2), $U = 11{,}441$, $z = -3.87$, $p < .001$. A visual illustration of the differences between pilot groups was provided in Figure 4.9. These findings indicate that NCTPs required more lessons than CTPs to complete the Commercial Flight I course. Therefore, the null hypothesis was rejected.

Supplemental null hypothesis S1b: Students who obtained a private pilot certificate from a non-collegiate program will require the same number of lessons attempts in the instrument pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The Mann-Whitney U test of the Commercial Flight I course lesson attempts identified no statistically significant difference between CTPs (*Mdn* = 15) and NCTPs (*Mdn* = 14), $U = 5{,}630$, $z = 1.48$, $p = .14$. A visual illustration of the similarities between pilot groups was provided in Figure 4.10. Therefore, the null hypothesis was accepted.

Supplemental null hypothesis S1c: Students who obtained a private pilot certificate from a non-collegiate program will require the same number of lessons attempts in the second third of residential collegiate commercial pilot training compared to students who obtained a private pilot certificate from a residential collegiate program. The Mann-Whitney U test of the Commercial Flight II course lesson attempts revealed no statistically significant difference between CTPs (*Mdn* = 2) and NCTPs (*Mdn* = 2), $U = 8{,}275$, $z = -1.17$, $p = .24$. A visual depiction of the similarities between pilot groups was provided in Figure 4.11. Therefore, the null hypothesis was accepted.

Supplemental null hypothesis S1d: Students who obtained a private pilot certificate from a non-collegiate program will require the same number of lessons attempts in the final third of residential collegiate commercial pilot

training compared to students who obtained a private pilot certificate from a residential collegiate program. The Mann-Whitney U test of the Commercial Flight III course lesson attempts identified no statistically significant difference between CTPs (*Mdn* = 8) and NCTPs (*Mdn* = 7), U = 8,687, z = .99, p = .32. A visual illustration of the similarities between pilot groups was provided in Figure 4.12. Therefore, the null hypothesis was accepted.

Chapter 5

Conclusions, Implications, and Recommendations

Purpose of Study

The purpose of this study was two-fold. The first was to examine the difference in pilot performance in commercial and instrument flight students who had obtained a private pilot certificate from a residential collegiate flight program compared to students who had obtained a private pilot certificate from a non-collegiate flight program. The second was to examine the difference in time spent completing commercial and instrument flight courses between students who obtained a private pilot certificate from a residential collegiate flight program compared to students who obtained a private pilot certificate from a non-collegiate flight program. Additionally, a supplemental analysis was conducted to examine the difference in lesson attempts in completing commercial and instrument flight courses between pilot groups.

The target population for the proposed study was all collegiate aviation flight students. The accessible population for the proposed study was all residential flight students enrolled in the Mid-Atlantic region collegiate bachelor's degree program at the host university.

The methodology and design for this study was a quantitative, ex post facto, effects-type design consisting of one IV and sixteen DVs. The IV was the type of private pilot flight training an individual completed when obtaining a private pilot certificate; group membership was based on the type of flight training (CTP or NCTP). DVs were Y_1 = Pilot performance in AVIA 325, Commercial Flight I; Y_2 = Ground time required to complete AVIA 325, Commercial Flight I; Y_3 = Flight time required to complete AVIA 325, Commercial Flight I; Y_4 = Pilot performance in AVIA 320, Instrument Flight; Y_5 = Ground time required to complete AVIA 320, Instrument Flight; Y_6 = Flight time required to complete AVIA 320, Instrument Flight; Y_7 = Pilot performance in AVIA 326, Commercial Flight II; Y_8 = Ground time required to complete AVIA 326, Commercial Flight II; Y_9 = Flight time required to complete AVIA 326, Commercial Flight II; FTD time required to complete AVIA 320, Instrument Flight; Y_{10} = Pilot performance in AVIA 327, Commercial Flight III; Y_{11} = Ground time required to complete AVIA 327, Commercial Flight III; Y_{12} = Flight time required to complete AVIA 327, Commercial Flight III. Supplemental DVs considered in this study were: Y_{13} = Lessons required to complete AVIA 325, Commercial Flight I; Y_{14} = Lessons required to complete AVIA 320, Instrument Flight; Y_{15} = Lessons required to complete AVIA 326, Commercial Flight II; and Y_{16} = Lessons required to complete AVIA 327, Commercial Flight III.

Summary of Findings

Data used in the study was collected utilizing a census of existing student data, progress reports, and records contained in the university's archived flight management system. Data was extracted from the archived database by an assigned host university database SME and provided to a flight records SME in compliance with IRB data handling requirements. Prior to deidentification of the dataset by the flight records SME, each student record was categorized by IV group membership and assigned a reference number to satisfy record independence and improve internal validity. The sample group for the proposed study included a census of all the commercial and instrument flight students between August 2015 and August 2020. The initial flight record sample size was $N = 583$. After performing preliminary data analysis, the final sample consisted of $N = 412$.

Independent-samples *t* tests were performed on each RPL variable. Sample sizes for each test by course were as follows: Commercial Flight I, $N = 337$; Instrument Flight, $N = 208$; Commercial Flight II, $N = 277$; and Commercial Flight III, $N = 262$. Preliminary analysis of each dataset included missing data, outlier analysis, and assumption testing. An independent-samples *t* test on each course identified no significant effects.

MANOVAs were performed for each course on the time related variables. Samples sizes for each test by course were Commercial Flight I, $N = 351$; Instrument Flight, $N = 208$; Commercial Flight II, $N = 274$; and Commercial Flight III, $N = 262$. Preliminary analysis of each dataset included missing data, outlier analysis, and assumption testing. The Commercial Flight I MANOVA was statistically significant. Follow-up univariate ANOVAs identified a statistically significant difference in ground instruction time between CTPs and NCTPs but no difference in flight time. All other MANOVAs revealed no significant effects in the Instrument Flight, Commercial Flight II, and Commercial Flight III courses.

As a supplemental analysis, Mann-Whitney U tests were performed for the lesson attempt variable of each flight course. Sample sizes by course were Commercial Flight I, $N = 351$; Instrument Flight, $N = 208$; Commercial Flight II, $N = 274$; and Commercial Flight III, $N = 262$. Preliminary analysis of each dataset included missing data, DV group distribution shape comparison, and assumption testing. The Commercial Flight I Mann-Whitney U test identified a statistically significant difference in the number of lesson attempts between CTPs and NCTPs. The other Mann-Whitney U tests revealed no significant effects in any of the other courses. Table 5.1 presents the results of primary hypothesis testing. Table 5.2 presents the results of supplemental hypothesis testing. The following section summarizes the results of the primary, supplemental, and follow-up analyses.

Table 5.1

Summary of Primary Hypotheses Tests Results

	Null Hypothesis	Decision
1a	NCTPs will demonstrate the same level of flight training performance in the first third of residential collegiate commercial pilot training compared to CTPs.[a]	Accepted[c]
1b	NCTPs will demonstrate the same level of flight training performance in instrument pilot training compared to CTPs.[a]	Accepted[c]
1c	NCTPs will demonstrate the same level of flight training performance in the second third of residential collegiate commercial pilot training compared to CTPs.[a]	Accepted[d]
1d	NCTPs will demonstrate the same level of flight training performance in the final third of residential collegiate commercial pilot training compared to CTPs.[a]	Accepted[d]
2a	NCTPs will require the same amount of time to complete the first third of residential collegiate commercial pilot training compared to CTPs.[b]	Rejected[e]
2b	NCTPs will require the same amount of time to complete instrument pilot training compared to CTPs.[b]	Accepted[c]
2c	NCTPs will require the same amount of time to complete the second third of residential collegiate commercial pilot training compared to CTPs.[b]	Accepted[d]
2d	NCTPs will require the same amount of time to complete the final third of residential collegiate commercial pilot training compared to CTPs.[b]	Accepted[d]
2d	NCTPs will require the same amount of time to complete the final third of residential collegiate commercial pilot training compared to CTPs.[b]	Accepted[d]

Note: N_{Total} = 412

[a]Hypotheses were tested using independent-samples t test with type of private pilot training as the IV and pilot performance (RPL scores) as DVs. [b]Hypothesis was tested using one-way MANOVA with type of private pilot training as the IV and training time, by course as DVs. [c]α = .05 adjusted to .025 for Bonferroni factor. [d]α = .025 adjusted to .013 for Bonferroni factor. [e]Null Hypothesis 2a was rejected as univariate follow-up analysis revealed statistically significant difference in Commercial Flight I ground time required between CTPs and NCTPs.

Table 5.2
Summary of Supplemental Hypotheses Tests Results

	Null Hypothesis	Decision
S1a	NCTPs will require the same number of lessons to complete the first third of residential collegiate commercial pilot training compared to CTPs.[a]	Rejected[b]
S1b	NCTPs will require the same number of lessons to complete the instrument pilot training compared to CTPs.[a]	Accepted[c]
S1c	NCTPs will require the same number of lessons to complete the second third of residential collegiate commercial pilot training compared to CTPs.[a]	Accepted[c]
S1d	NCTPs will require the same number of lessons to complete the final third of residential collegiate commercial pilot training compared to CTPs.[a]	Accepted[c]

Note: $N_{Total} = 412$
[a]Hypotheses were tested using Mann-Whitney U test with type of private pilot training as the IV and lesson attempts as the DV. [b]Null Hypothesis S1a was rejected. A statistically significant Mann-Whitney U test revealed statistically significant difference in Commercial Flight I lesson attempts between CTPs and NCTPs. $\alpha = .05$ adjusted to .025 for Bonferroni factor. [c]$\alpha = .025$ adjusted to .013 for Bonferroni factor.

Conclusions and Inferences

In the following section, the findings from the study are presented and discussed relative to the research questions and terms defined in Chapter 1. Results are described in relation to the corresponding research questions, along with interpretations of those findings in the context of the research settings. Plausible explanations for the findings are also presented.

Research question 1a: What was the difference in pilot performance during the first third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and

students who obtained their private pilot certificate from a non-collegiate program? The independent-samples *t* test on Commercial Flight I course RPL scores revealed no significant difference between CTP and NCTP pilot performance (CTP (M = 670, SD = 168), NCTP (M = 671, SD = 185), 95% CI [-39, 37], $t(335) = -.05$, $p = .96$). This insignificant finding between CTP and NCTP groups indicates each group performed equally as well on the initial attempt of each flight lesson in the Commercial Flight I course. Although the findings of this test were insignificant, the NCTP group *SD* is slightly larger than the CTP group *SD* (see Table 4.2). A larger *SD* indicates the NCTPs RPLs were less standardized and may reflect the less standardized type of private pilot training they had experienced. One plausible explanation for these results is relevant to the subjectivity of the evaluation process and instrument. Although there was evidence the evaluation process and FAA certification standards were strictly adhered to by the host university, there remains an element of human subjectivity in the evaluation process. Attempts to mitigate the evaluation subjectivity employed by the host university included the use of an approved set of performance standards outlined in each TCO, standardized instructor pilot training conducted after initial hiring and on a recurring annual basis, and annual instructor certifications for each course taught by the instructor. Standardized training and evaluation processes may have improved the training experience and atmosphere and reduced the breadth and depth of training variances. However, fidelity in assessing pilot performance on a 5-point scale by another human being is limited and remains subjective.

A second plausible explanation is the scale on which pilot performance was evaluated during training. The grading scale used in assessing student performance in each of the flight courses was a 5-point scale. A detailed explanation of the RPL grading scale was provided in Chapter 3 of this study. Although the use of a 5-point scale facilitates reduced time in assessing an individual's performance across multiple observed lesson line items, the lack of measurement sensitivity in a 5-point scale does not facilitate precise observations of performance differences.

A third plausible explanation is that the FAA standards demonstrated at the private pilot level satisfactorily prepared pilots to progress into commercial pilot training, regardless of the type of training program experienced in private pilot training.

Research question 1b: What was the difference in pilot performance during instrument flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The independent-samples *t* test on Instrument Flight course RPL scores revealed no significant differences between CTP and NCTP pilot performance (CTP (M = 1589, SD = 237), NCTP (M = 1646, SD = 214), 95% CI [-122, 8], $t(206) = 1.71$, p = .08). Although this was not as hypothesized, there was no difference in performance measured between the two pilot groups. A plausible explanation is that no significant difference in pilot performance exists between pilot groups when completing collegiate instrument flight training. A second plausible explanation is that it should be expected that there will be no difference in performance between student groups in any flight training course that occurs after establishing standardized initial flight training in the preceding flight course. Specifically, one goal of developing and using a CFR Part 141 approved flight course in collegiate flight training is to establish a standardized training program that produces a standardized pilot capable of transitioning into a profession in the aviation industry. Therefore, it should be expected that once a set of standardized training results is established between groups, the approved training approach found in a CFR Part 141 collegiate flight training program should sustain standardized results in subsequent training.

Research question 1c: What was the difference in pilot performance during the second third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? As hypothesized, the independent-samples *t* test on Commercial Flight II course RPL scores revealed no significant difference between CTP and NCTP pilot performance (CTP (M = 1508, SD = 1102), NCTP (M = 1476, SD = 1057), 95% CI [-228, 293], $t(275) = .24$, $p = .81$). Two plausible explanations are similar to those described above in research question 1b.

Research question 1d: What was the difference in pilot performance during the final third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? As expected, the independent-samples *t* test on Commercial Flight III course RPL scores revealed no significant difference between CTP and NCTP pilot performance (CTP ($M = 2031$, $SD = 435$), NCTP ($M = 2075$, $SD = 420$), CI [-156, 69], $t(236) = .05$, $p = .45$). Two plausible explanations are similar to those described above in research question 1b.

Research question 2a: What was the difference in time spent during the first third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The Commercial Flight I course between-subjects MANOVA indicated a statistically significant difference between CTP and NCTP groups, $F(2, 348) = 16.8$, $p < .01$; Wilks' $\Lambda = .91$; partial $\eta^2 = .09$. A follow-up univariate ANOVA identified a statistically significant difference between pilot groups in ground instruction time ($F(1, 349) = 33.8$, $p < .001$; partial $\eta^2 = .09$). There was no significant difference between CTPs and NCTPs in flight time during the

Commercial Flight I course (*F*(1, 349) = 2.5, *p* = .12; partial η^2 = .01). These findings indicate that NCTPs required more ground instruction time than CTPs to complete the Commercial Flight I course. When comparing group means (CTP *M* = -4.2, NCTP *M* = -2.0), NCTPs required an average of 2.2 additional hours of ground instruction than CTPs. Furthermore, the NCTP group had a larger *SD* than the CTP group (CTP *SD* = 3.2, NCTP *SD* = 3.8) indicating a less standardized amount of time required to complete the course. This larger NCTP group *SD* may reflect the less standardized type of private pilot training they had experienced. The only observed time related difference between pilot groups in the Commercial Flight I course was in ground instruction required. No difference in flight time required was observed between pilot groups in the Commercial Flight I course. Therefore, it can be interpreted that although NCTPs required additional ground time to complete Commercial Flight I, they required approximately the same amount of flight time as CTPs. These negative standardized training times should be interpreted based on TCO planned minimum time. This occurrence is reasonable given that TCO time requirements, not individual course planned times, must be satisfied prior to beginning the applicable FAA practical examination. As depicted in Figure 1.1, the host university's commercial pilot flight training program consists of three courses with the Commercial Pilot TCO. In the current example, the minimum times required by the TCO must be met prior to the commercial pilot practical evaluation that occurs after completion of the Commercial Flight III course. Thus, while the ground time for a student may be less than the TCO planned times for one course, when the ground times for all three courses are added together, the summed total of all three courses must meet or exceed the specified minimum hours required for the TCO.

One plausible explanation for these results is that CTPs, who had completed private pilot training in the same program, had previously learned the unique policies and procedures of the host university's flight operations and training during private pilot training. NCTPs, on the other hand, did not have any prior experience with the unique requirements associated with the host university's flight training and operations. This time difference would be expected in the flight time required between pilot groups. However, it may be plausible that flight instructors recognized in NCTPs a lack of familiarity with the host university's policies and procedures and spent more ground time with the student discussing and familiarizing the student with the school's Flight Operations Manual and other associated policies and procedures. Once the NCTPs had experienced a semester of flight operations with the host university, no additional time was required.

A second plausible explanation is that additional time was required by NCTPs to adapt to the type of aircraft used by the host university. Although a discussion on pilot adaptation to different types of aircraft instrumentation was provided in Chapter 2 of this study (Lindo, et al., 2012), there may still be some period of adjustment and adaptation that was realized in the current study. Training time difference would be expected in the flight time required between pilot groups. However, it may be plausible that flight instructors recognized in NCTPs a lack of familiarity with the host university's aircraft type and spent more ground time with the student discussing aircraft characteristics, capabilities, limitations, and operations. As such, additional ground time may have been required by the NCTPs to become familiar with the aircraft used by the host university. Once the NCTPs adapted to the change in aircraft type and achieved familiarity with the host university's aircraft, subsequent courses did not require additional time.

A third plausible explanation for the difference in time spent between pilot groups may be the result of preexisting instructor perception bias. Foundational to the genesis of the current study, anecdotal perceptions and expectations within the collegiate flight training environment of a difference between pilot groups may have either intentionally or unintentionally influenced instructor training and grading behavior that resulted in a positive or negative halo effect when training CTPs or NCTPs, respectively.

A fourth plausible explanation may be found in purpose and intent of collegiate flight training and the inherent professional level of knowledge expected of collegiate flight students. The underlying purpose and intent of collegiate flight training is to prepare individuals to become professionals in the aviation industry. Individuals who attend a collegiate flight training program are presented with professional level expectations at every level of the education experience, beginning with private pilot training. In a residential collegiate flight training program that is focused on professional pilot development, a higher level (commercial pilot) of ground instruction is being taught earlier with the expectation that students attending a residential collegiate flight training program are there in pursuit of a professional level of knowledge and performance. On the other hand, non-collegiate flight training environments may be less regulated and more focused on satisfying the minimum requirements for private pilot training, not professional pilot training. Therefore, Commercial I flight instructors may have observed less than the expected professional level of knowledge in the NCTPs and supplemented the required ground time with additional time. If this were the case, once the expected knowledge level was corrected in the first commercial pilot course, subsequent courses would not require additional time.

Each of the preceding plausible explanations is further supported by the findings from the lesson attempts supplemental analysis (see Supplemental Analysis 1 below; see also Table 5.2). NCTPs not only required more ground time to complete the Commercial Flight I course, but they also required additional lessons. A plausible explanation is that the additional time required by NCTPs was completed through the use of additional or repeated lessons to satisfy minimum learning objectives for each lesson.

Research question 2b: What was the difference in time spent during instrument flight training between flight students who obtained a private pilot

certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The Instrument Flight course between-subjects MANOVA indicated no statistically significant difference between CTP and NCTP groups, $F(2, 205) = .3$, $p = .72$; Wilks' $\Lambda > .99$; partial $\eta^2 < .01$. Follow-up univariate ANOVA results are presented in Table 4.14 for the benefit of the reader. It was hypothesized that NCTPs would require more time in instrument pilot training compared to CTPs. However, results found no significant difference in the same amount of time required to complete the Instrument Flight course between pilot groups. The results of the MANOVA and underlying univariate ANOVAs indicate no significant difference in group means with very small effect size.

A plausible explanation is that no significant difference in time spent exists between pilot groups when completing collegiate instrument flight training, or at least none exists after initial commercial flight training. A second plausible explanation is that no difference in flight or ground training times would exist in any course that occurs after initial standardization. Thus, after establishing standardized results between the two groups in the initial commercial training, there would be no further detectable differences. As described previously in this chapter, once a set of equivalent training results are established between groups, it is reasonable that a CFR Part 141 collegiate flight training program should sustain similar results in subsequent courses.

Research question 2c: What was the difference in time spent during the second third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? As expected, The Commercial Flight II course between-subjects MANOVA indicated a statistically significant difference between CTP and NCTP groups, $F(2, 271) < .1$, $p = .96$; Wilks' $\Lambda > .99$; partial $\eta^2 < .01$. Follow-up univariate ANOVAs results were presented in Table 4.14 for the benefit of the reader. Two plausible explanations are similar to those described above in research question 2b. As expected, CTPs and NCTPs required approximately the same amount of time to complete the Commercial Flight II course. The results of the MANOVA and underlying univariate ANOVAs indicates no significant difference in group means with a less than one percent effect size.

Research question 2d: What was the difference in time spent during the final third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? As expected, The Commercial Flight III course between-subjects MANOVA indicated a statistically significant difference between CTP and NCTP groups, $F(2, 259) = 2.6$, $p = .08$; Wilks' $\Lambda = .98$; partial $\eta^2 = .02$. Follow-up univariate ANOVAs results were presented in Table 4.14 for the benefit of the reader. Two plausible explanations are similar to those described above in research question 2b. It was hypothesized that CTPs and NCTPs would require approximately the same amount of time to complete the Instrument Flight course. The results of the MANOVA indicate no significant difference in group means and a very small effect size. Although the MANOVA was not significant and no further analysis was required, for the benefit of the reader, the results of the underlying univariate ANOVAs are presented here for completeness. When comparing the results of the underlying univariate ANOVAs (see Table 4.13), there was a notable difference in flight time required between pilot groups. The NCTP group required less time (CTP M = 3.1, NCTP M = 1.7) and exhibited a small SD (CTP SD = 5.2, NCTP SD = 4.0) than the CTP group. Regardless, these results indicate no statistically significant difference flight time required exists between pilot groups.

Supplemental question S1a: What was the difference in lessons required during the first third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The Mann-Whitney U test of the Commercial Flight I course lesson attempts identified a statistically significant difference between CTPs (*Mdn* = 1) and NCTPs (*Mdn* = 2), U = 11,441, z = -3.87, $p < .01$. A significant difference in M Rank (CTP = 159, NCTP = 200) and frequency distribution between pilot groups was observed (see Figure 4.9). It was hypothesized that NCTPs would require more lessons in the Commercial Flight I course than CTPs. However, when comparing the median numbers between pilot groups, the difference was one lesson, over the course a semester. Although the test result is statistically significant, the value of this finding may not be as substantive in practice. The average number of Commercial Flight I lessons prescribed by the Commercial Pilot TCO is 21 lessons conducted over the course of a college semester. The addition of one lesson in a sixteen-week period is seemingly easy to accommodate. Although the addition of a lesson over the course of a college semester may be simple to accommodate logistically, an additional lesson and more specifically the added time and cost may seem more consequential to the individual spending the time and money. A plausible explanation is that in conjunction with the previously described finding that NCTPs required more time than CTPs to complete the Commercial Flight I course, the additional time may have also necessitated requiring an additional or repeated lesson.

Supplemental question S1b: What was the difference in lessons required during instrument flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The Mann-Whitney U test of the Commercial Flight I course lesson attempts revealed no statistically significant difference between CTPs (*Mdn* = 15) and NCTPs (*Mdn* = 14), $U = 5{,}630$, $z = 1.48$, $p = .14$. A notable difference in *M*

Rank (CTP = 109, NCTP = 96) and frequency distribution between pilot groups was observed (see Figure 4.10). Visual interpretation of the results indicate CTPs were more standardized with a more concentrated frequency of median attempts than NCTPs. It was hypothesized that NCTPs would require more lessons in the Instrument Flight course compared to CTPs. However, results found no significant difference in the number of attempts required to complete the Instrument Flight course between pilot groups. As described previously in this chapter, once a set of equivalent training results are established between groups, it is reasonable that a CFR Part 141 approved collegiate flight training program should sustain similar results in subsequent courses.

Supplemental question S1c: What was the difference in lessons required during the second third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The Mann-Whitney U test of the Commercial Flight II lesson attempts identified no statistically significant difference between CTPs (*Mdn* = 2) and NCTPs (*Mdn* = 2), $U = 8{,}275$, $z = -1.17$, $p = .24$. No significant difference in *M* Rank (CTP = 133, NCTP = 144) or frequency distribution between pilot groups was observed (see Figure 4.11). It was hypothesized that NCTPs would require the same number of lessons in the Commercial Flight II course compared to CTPs. This result was as expected. As described previously in this chapter, once a set of equivalent training results are established between groups, it is reasonable that a CFR Part 141 approved collegiate flight training program should sustain similar results in subsequent courses.

Supplemental question S1d: What was the difference in lessons required during the final third of commercial flight training between flight students who obtained a private pilot certificate from a residential collegiate program and students who obtained their private pilot certificate from a non-collegiate program? The Mann-Whitney U test of the Commercial Flight II lesson attempts revealed no statistically significant difference between CTPs (*Mdn* = 8) and NCTPs (*Mdn* = 7), $U = 8{,}687$, $z = .99$, $p = .32$. No significant difference in *M* Rank (CTP = 135, NCTP = 126) or frequency distribution between pilot groups was observed (see Figure 4.12). It was hypothesized that NCTPs would require the same number of lessons in the Commercial Flight III course compared to CTPs. This result was as expected. As described previously in this chapter, once a set of equivalent training results are established between groups, it is reasonable that a CFR Part 141 approved collegiate flight training program should sustain similar results in subsequent courses.

Implications

The following section presents the implications relative to (a) prior research and (b) aviation practice.

Implications relative to prior research. Published research in comparing student pilot performance and time requirements between collegiate and non-collegiate training is limited. Recent studies by Robertson and Harrison (2008) and Smith et al. (2010 & 2013) explored anecdotal perceptions that suggested there was a difference between flight instruction methods. Findings from the current study build upon existing research and contribute to a greater understanding of collegiate flight training.

The current study revealed that CTPs required fewer ground instruction hours than NCTPs in the first commercial pilot flight course after private pilot having received a private pilot certificate. This may indicate that the CTPs were better prepared to begin the transition from being a recreational pilot status to becoming a professional pilot. As Smith et al. (2010 & 2013) identified and subsequently verified, a structured and standardized approach to flight training produced a higher quality, more capable commercial pilot. Smith, et al. (2010 & 2013) focused their studies on pilot performance in the marketplace, after a pilot had transitioned into a professional status. The current study sought to better understand the professional pilot development process. Thus, this study offers a better understanding of where differences in pilot development between CTPs and NCTPs may be occurring.

Although the results in the current study indicated that NCTPs required additional ground instruction time in the first semester of commercial flight training, they did not reveal any significant amount of additional flight time was required. Further analysis of time spent in each subsequent flight course, resulted in no statistically significant differences between pilot groups. Therefore, the current study further supports the expectation that every private pilot was adequately prepared to successfully satisfy the host university's TCO training standards in preparation for FAA PTS or ACS requirements as a part of the FAA pilot certification process, regardless of the method or program of private pilot instruction (Acur et al., 2015; FAA, 2011; FAA, 2013; FAA, 2018; Knecht & Pittorie, 2018; Smith, 2012).

The current study complements the Robertson and Harrison's (2008) SIU study that concluded when comparing days of training, instrument training completion rates, and degree completion rates, there were no statistically significant differences between native and transfer private pilots. Furthermore, they concluded that within the transfer category of students, there were no statistical difference between students who completed the transition course and those students who were permitted direct entry into the flight program, confirming that after the transition course, there were no differences between the categories of students (Roberston & Harrison, 2008). Similarly, the current study found that there was no statistically significant difference in performance or flight training time between CTPs and NCTPs. However, there was a difference in ground instruction time between CTPs and NCTPs that was not directly assessed in the Robertson and Harrison study.

Roberston and Harrison sought quantitative evidence to validate the effectiveness of the SIU developed transition course and the transfer student policies implemented by SIU to mitigate an anecdotal perception that students who had obtained a private pilot certificate prior to beginning flight training at SIU did not perform as well as those who had obtained a private pilot certificate with SIU. However, they did not present data on quantitatively assessed differences in student groups prior to implementing the transition course. Through implementation of policy and a required transition course for transfer students, SIU had already increased the transfer student's instruction time to account for anecdotal evidence of inferior transfer student performance. The current study produced similar flight training results that seem to corroborate the Harrison and Robertson's (2008) findings that no statistically significant difference between pilot groups exists. However, the current study provides quantitative evidence of a statistically significant difference in ground instruction time required by NCTPs during the first semester of commercial flight training in a collegiate program, not previously published.

Implications for Aviation Practice. Implications for the aviation education community are important to consider, for both individuals and the collegiate aviation community. As the predicted commercial pilot shortage continues to loom on the horizon, the aviation industry will seek professionally trained pilots in the most time efficient means possible. Countering the industry's time constrained need for professional pilots to support global aviation demand is the increasing costs associated with flight training. These factors influence individuals seeking a profession in the aviation industry to weigh the available flight education and training options. Students may seek a less expensive and faster route to obtain a private pilot certificate with the perception that they will save time and money in the pursuit of a professional education and flight training. Findings from the current study indicate that CTPs require less time and fewer lesson attempts than NCTPs in the first semester of their commercial flight training. Although these findings were statistically significant with a medium to large effect size, consideration of the differences in time spent and completed lessons should be evaluated as a part of the flight training decision process. Specifically, when considering the mean number of ground instruction hours required by CTPs in the Commercial Flight I course (M = -4.2 hours) compared to the mean number of hours required by NCTPs (M = -2.0), the difference in ground instruction is 2.2 fewer hours required by the CTPs. The additional 2.2 hours of ground instruction aligns with the supplemental analysis finding that indicated NCTPs required one additional lesson to complete the Commercial Flight I course. Of note, the average duration of each Commercial Flight I ground lesson was 2.5 hours. A difference of 2.2 hours of ground instruction should be considered when evaluating other advantages and disadvantages associated with each type of private pilot training. An additional 2.2 hours of ground instruction may provide sufficient training to effectively standardize NCTPs time with CTPs. However, it should be expected that 2.2 hours of supplemental ground instruction may not be sufficient to standardize every NCTP pilot.

Similarly, implications of the current study on collegiate flight training programs should be considered as the flight training industry experiences continuous and steady growth. As the expected pilot shortage looms on the horizon and student populations steadily grow on an annual basis to meet the aviation industry's increased pilot production demands, collegiate flight training programs may struggle to keep pace. To meet expected or actual flight student growth, flight programs will be required to invest large amounts of capital funds to purchase the necessary aircraft, simulators, and facilities needed to host a rising population of flight students. In addition to the cost of the necessary physical resources to keep up with expected or actual student growth, human capital investments will be required through the hiring of additional flight instructors. Likewise, as students are faced with the rising flight training costs, they may begin to explore cheaper and faster private pilot flight training options. In turn, as collegiate flight programs begin to experience increasing pressure to manage their limited training aircraft fleet and human resources, they may choose (as the host university has already done) to effectively outsource their private pilot training by providing academic credit for students who obtain a private pilot flight certification from a non-collegiate program. In doing so, the collegiate flight training program should consider the findings of the current study in accepting prior private pilot training certifications and awarding academic credit for prior training. Collegiate program administrators should consider mitigation strategies, including the development of a transition or orientation course for NCTPs, to facilitate a smoother more standardized NCTP transition into the collegiate flight training experience.

Aviation regulatory bodies, such as the FAA, may also consider findings of the current study beneficial in understanding the differences present in collegiate and non-collegiate flight training. Continued increased demand for aviation education services and the anecdotal perception that non-collegiate private pilot flight training is cheaper and faster but offers the same quality of certification through the ACS requirement, may create an even greater trend away from professionally focused collegiate private pilot training toward recreationally focused private pilot training program. The resultant shift may burden the training capacity of the collegiate programs and drive an even more expedited, less rigorous private pilot training experience.

Generalizability, Limitations, and Delimitations

Generalizability. External validity is related to the extent that the current study can be applied to other populations and settings. External validity encompasses two types of generalization, those being population and ecological validity. Population validity refers to how likely the results may extend beyond the sampled population. The data in the current study was a census of the available flight records at the host university. A census of the accessible population was desired to improve the external validity of the study. However, because the data in the current study was deidentified and no further specific demographic information on accessible population was made available, the results of the current study may be generalized to the target population of the United States when host university demographics, as presented in Chapter 3 and 4, are similar.

The second type of generalizability is ecological validity and is focused on the conditions of the study environment and how those conditions apply to different settings, conditions, or circumstances. Methods, designs, materials, and settings each impact the ecological validity of the current study. The current study involved a collegiate flight training program approved under CFR Part 141 to provide flight instruction at the Private, Instrument, and Commercial certificate levels. The Air Agency Certificate issued to the host university by the FAA specifies a specific set of approved TCOs that shall be utilized when providing flight instruction under CFR Part 141. The TCOs used by the host university are unique and specific to the host university. Other collegiate programs operate under CFR Part 61 regulations or CFR Part 141 regulations with a different, but similar set of approved TCOs unique to that program. Although TCOs are unique and specific to each flight training program they support, each TCO is reviewed and approved by the FAA through the local FSDO. The collegiate program was uniquely designed to integrate commercial and instrument flight training over four sequential semesters (Figure

1.1). The program also utilized a highly trained and certified cadre of CFIs of whom a high percentage were recent graduates of the program. The host university utilized a very well-maintained modern fleet of TAA C-172 and PA-44 aircraft. The current study used data from a collegiate program located in the mid-Atlantic region of the United States with relatively flat farmland extending East and South of the base of operations and mountainous terrain extending North and West. Extending the results of the current study beyond similar conditions may not be suitable and may present different findings.

Study limitations and delimitations. The current study experienced limitations and was delimited in several aspects as presented in Chapter 1 and, for ease of the reader, here.

Limitations. Limitations of the current study included instructor grading variations, aircraft maintenance, weather impacts to flight operations, student financial issues, and CFI / student interpersonal interactions. Concerns related to potential instructor grading variations and mitigation strategies through the collegiate program hiring and CFR Part 141 initial and recurring certification process were discussed in Chapter 1 of this study. To leverage the learning laws of exercise and recency, students were scheduled for a minimum of two or three training activities per week. Occasionally, due to unpredictable weather or maintenance occurrences, the minimum number of flight activities was not achieved within the planned weekly activities and may have detracted from an optimum and consistent training cycle. Prior to beginning flight trainings, students were required to provide funds to cover the associated lab fee adjusted to cover all flight related expenses based on historical data covering the average cost of 90% of previous graduates in order to decrease the likelihood of this occurrence. In some instances, if the student had exhausted the prepaid lab fee funds, an interruption in training may have occurred until the student was able to secure additional funds. Anecdotally, student-CFI interpersonal relationship conflicts were a very rare occurrence. A pilot's ability to exercise strong interpersonal relationship skills and maintain a professional environment in the aviation industry is an essential element of continued safe operations. As a preventative measure, the host university provided each CFI education and protocols to adjust and adapt instructional methods and techniques to accommodate most student learning behaviors.

Delimitations. The current study was delimited to the archived flight student records of one Mid-Atlantic region collegiate bachelor's degree program spanning a 5-year period between 2015 and 2020. An ex post facto methodology was used with group membership (type of private pilot training) of the IV having been already established. DVs were selected based on the availability of detailed flight record data from a large group of collegiate flight students. Within the available flight record database, the dataset consisted of a census of the available records delimited to the data related to the commercial and instrument flight courses that supported the FAA approved TCOs. Flight data records for other courses offered by the host university were not included in this study. Only records of students in a degree completion plan that required both commercial and instrument flight training were considered in the current study. RPL scores were the summation of the grade assigned by the CFI for the first attempt of each line item in each lesson. Grades assigned for additional or repeated lessons were not included in the RPL sum. All recorded ground and flight time, including additional or repeated lessons, were considered in this study. For the supplemental analysis, every lesson, including additional or repeated lessons, were counted.

Recommendations for Future Research and Practice

Recommendations for Research Relative to Study Limitations.

1. Although efforts were made to standardize student performance grading, subjective human-derived grading was the primary method of recording student pilot performance. Two recommendations to further mitigate subjective grading effects are:
   a. Align future research between pilot groups under individual CFIs. This would standardize the subjectivity of the observer. This type of research could be accomplished with an ex post facto design that identified individual CFIs as a covariate IV.
   b. Future research may leverage continuing advancements in computing power and onboard flight parameter data collection capabilities to quantitatively analyze and assess student performance. The host university

is currently using the G1000 avionics suite to record all aircraft performance and flight parameters for use in maintenance troubleshooting and safety of flight concerns, respectively. Because the flight parameter data is already being captured with IFR certified levels of accuracy, analysis of collected flight data may provide an automated process to grade student maneuvers.

2. Seasonal environmental conditions and trends, such as icing conditions in the winter, breezy winds during the spring, and afternoon thunderstorms during the summer, can limit flight training in the geographic location of the host university. Future research should consider other geographic locations that may experience fewer weather-related interruptions in training and / or incorporate weather related data (e.g., a reason for lesson cancellation variable) to control for this cause of training delay.
3. The current study utilized a standardized fleet of TAA C-172 and PA-44 aircraft. Future studies may benefit from other less advanced aircraft or aircraft produced by other manufacturers.

Recommendations for Research Relative to Study Delimitations.

1. The current study employed an ex post facto study of archived data to facilitate an efficient research process and results across all four semesters of commercial and instrument flight training. The breadth of the current study did not permit an in-depth review and analysis of pilot performance and time spent on each

line item within each lesson within each course. Future ex post facto research should consider narrowing the scope of study with a more in-depth line-item review and analysis within a single semester course following private pilot certification. In the context of the host university's program, future studies should consider delimiting the scope to the first or the first two courses beyond private pilot certification. Follow-on analyses of the pilot performance and time spent may provide additional insight to differences between pilot groups throughout the instructional and development process.

2. The current study's primary analysis was focused on the quantitative aspects of commercial and instrument flight training. Although this addressed the anecdotal perception that NCTPs may not initially perform (RPLs and time) as well as CTPs, it did not address the qualitative aspects of the anecdotal perception. Future research should consider a mixed methods design. This recommendation may include development of an experimental design with standardized FTD-based entry and exit evaluation (i.e., pretest-posttest control-group design) of each student in each course. Additionally, the qualitative component of the mixed methods design would include open-ended questions presented to CFIs and flight students to identify other areas where flight students experience poorer initial performance.
3. The current study was delimited to the accessible population and was conducted with deidentified data to protect the flight students' data and identities. The

student demographics of the host university may not represent other collegiate programs. Future research should consider other collegiate programs with differing student demographics and replicate the study in those 141 programs to establish the generalizability of the results to the target population.

Recommendations for Future Research Relative to Implications. The following section discusses recommendations based on implications discussed within this chapter. The current study found that NCTPs, when compared to CTPs, required additional ground instruction time to complete the first commercial pilot course after obtaining a private pilot certificate. The current study suggests that NCTPs lack some element or level of knowledge expected by the flight school administration. As a result of insufficient knowledge or depth of knowledge, CFIs are required to spend additional time with NCTPs to establish a standardized expected level of knowledge in the Commercial Flight I course.

1. Collegiate programs that currently accept NCTPs into their flight program with advance placement (e.g., the student bypasses the collegiate private pilot course and begins with either commercial or instrument training) should consider replicating the current study to determine if similar findings are present within their program.
2. Further research is needed to determine areas or levels in which NCTPs do not meet expected standards. This research may include a follow-up study by the host university that would entail a line-item review and analysis of student

performance, time spent, and lesson attempts within the Commercial Flight I course.

3. Collegiate programs with an existing flight operations orientation or familiarization course should consider replicating the current study as a method of determining if any differences between pilot groups persist after the required training has been completed.

Recommendations for Practice Relative to Implications. The current study complements the findings of Robertson and Harrison (2008) and provides previously unpublished quantitative data they did not consider. Robertson and Harrison (2008) concluded there was no difference between SIU native and transfer student pilot performance. Their study included an analysis of student training after the university had already implemented a policy that required transfer students complete a transition training course. The current study findings indicate that in the absence of any type of transition or operations orientation course, NCTPs required additional ground time than CTPs to complete the Commercial Flight I course. The additional training provided to the NCTPs was done so by the students' individually assigned CFI. Although the average additional ground time required was 2.2 hours, this additional time required for multiple students in an already time and resource constrained environment found in a collegiate flight operations department may be perceived as burdensome and time consuming. Therefore, the following recommendations are provided for the reader's consideration:

1. University flight programs should consider development of a sub-term, one college credit, Flight Operations Orientation course similar to other flight operations familiarization courses already in use at several mature collegiate flight programs around the United States (I. Silver, personal communication, June 17, 2021). The course should focus on developing or improving NCTPs' knowledge in four areas: flight operations policies and procedures, local airport and training area familiarization, aircraft equipment familiarization, and the maneuvers guide. Course completion standards may include a local area simulator training profile evaluation or written examination of course material that validate a minimum level of standardization has occurred prior to the student beginning the Commercial Flight I course. It is further recommended that universities establish a policy that requires all students who completed private pilot training elsewhere, to complete the locally developed flight operation orientation course prior to beginning any residential flight training.
2. Collegiate flight program administrators should consider developing a pre-course student handbook guide developed to inform NCTPs and reinforce CTPs relevant and necessary information considered foundational to student success in the Commercial Flight I course, or equivalent course based on the program specifics. Further consideration should be given to an evaluation process of the student handbook that may include remedial individualized supplemental training for identified weak areas of knowledge.

Conclusion

Professionally trained pilots have become some of the most trusted agents in every society around the world. Daily, pilots serve to deliver people, goods, and services globally in a safe, reliable, and timely manner. As the global pilot force ages at the same time that mobility and transportation needs increase, a professionally trained next generation of pilots is essential to retain the hard earned trust of the world. Understanding differences in foundational pilot training, beginning as early as private pilot certification, will foster continued aviation industry training process improvements. This study sought to explore commonly accepted anecdotal perceptions by quantifiably identifying actual differences between CTPs and NCTPs. The results of this study provide evidence that supports the perception that there is a measurable difference between CTPs and NCTPs. In the context of the current study, the difference between CTPs and NCTPs was most evident in the ground instruction time and lesson attempts of the first course after private pilot certification. The reader is encouraged to consider the implications and recommendations provided with this study as a starting point for further research or program improvements that will ultimately facilitate the education and training of the safest professional pilot in the most effective and efficient way possible.

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Appendix A

Knowledge Objectives associated with Instrument Airplane TCO

BROAD INSTRUMENT RATING ACS KNOWLEDGE OBJECTIVES These are objectives common to most of the flight training units in this course. Students are expected to fully achieve these objectives by the end of the course.
Be able to demonstrate ACS knowledge of single-pilot resource management. (01019)
Be able to demonstrate ACS knowledge of aeromedical factors. (02018)
Be able to demonstrate ACS knowledge of runway incursion avoidance. (03014)
Be able to demonstrate ACS knowledge of visual scanning & collision avoidance. (04007)
Be able to demonstrate ACS knowledge of the principles of flight. (05019)
Be able to demonstrate ACS knowledge of weight and balance. (06047)
Be able to demonstrate ACS knowledge of navigation and flight planning. (07113)
Be able to demonstrate ACS knowledge of night operations. (08007)
Be able to demonstrate ACS knowledge of the national airspace system. (10151)
Be able to demonstrate ACS knowledge of nav systems and radar services. (11050)
Be able to demonstrate ACS knowledge of certificates and documents. (121216)
Be able to demonstrate ACS knowledge of weather information. (13016)
Be able to demonstrate ACS knowledge of weather reports and charts. (14078)
Be able to demonstrate ACS knowledge of performance and limitations. (15017)
Be able to demonstrate ACS knowledge of airworthiness requirements. (16044)
Be able to demonstrate ACS knowledge of radio comms and ATC light signals. (17065)
Be able to demonstrate ACS knowledge of airport operations. (18048)
Be able to demonstrate ACS knowledge of airframes. (19006)
Be able to demonstrate ACS knowledge of flight controls and trims. (20006)
Be able to demonstrate ACS knowledge of powerplants. (21088)
Be able to demonstrate ACS knowledge of landing gear systems. (22018)
Be able to demonstrate ACS knowledge of fuel systems. (23016)
Be able to demonstrate ACS knowledge of hydraulic & pneumatic power systems. (24017)
Be able to demonstrate ACS knowledge of electrical systems. (25020)
Be able to demonstrate ACS knowledge of aircraft inst. systems and electronics. (26049)
Be able to demonstrate ACS knowledge of fire protection systems. (27008)
Be able to demonstrate ACS knowledge of cabin environmental control systems. (28013)
Be able to demonstrate ACS knowledge of ice and rain protection systems. (29015)

Knowledge Objectives associated with Instrument Airplane TCO (Liberty University School of Aeronautics, 14 CFR Part 141 Instrument Airplane Training Course Outline, Revision 1, 28 August 2017, p. C-7-2)

Appendix B

Knowledge Objectives associated with Commercial Pilot TCO

GENERAL COMMERCIAL COURSE PTS KNOWLEDGE OBJECTIVES These are objectives common to most of the flight training units in this course. Students are expected to fully achieve these objectives by the end of the course.
Be able to demonstrate PTS knowledge of single-pilot resource management. (01019)
Be familiar with the PTS special emphasis areas. (01020)
Be able to demonstrate PTS knowledge of aeromedical factors. (02018)
Be able to demonstrate PTS knowledge of runway incursion avoidance. (03014)
Be able to demonstrate PTS knowledge of visual scanning & collision avoidance. (04007)
Be able to demonstrate PTS knowledge of the principles of flight. (05019)
Be able to demonstrate PTS knowledge of weight and balance. (06047)
Be able to demonstrate PTS knowledge of navigation and flight planning. (07113)
Be able to demonstrate PTS knowledge of night operations. (08007)
Be able to demonstrate PTS knowledge of the national airspace system. (10151)
Be able to demonstrate PTS knowledge of nav systems and radar services. (11050)
Be able to demonstrate PTS knowledge of certificates and documents. (121216)
Be able to demonstrate PTS knowledge of weather information. (13016)
Be able to demonstrate PTS knowledge of weather reports and charts. (14078)
Be able to demonstrate PTS knowledge of performance and limitations. (15017)
Be able to demonstrate PTS knowledge of airworthiness requirements. (16044)
Be able to demonstrate PTS knowledge of radio comms and ATC light signals. (17065)
Be able to demonstrate PTS knowledge of airport operations. (18048)
Be able to demonstrate PTS knowledge of airframes. (19006)
Be able to demonstrate PTS knowledge of flight controls and trims. (20006)
Be able to demonstrate PTS knowledge of powerplants. (21088)
Be able to demonstrate PTS knowledge of landing gear systems. (22018)
Be able to demonstrate PTS knowledge of fuel systems. (23016)
Be able to demonstrate PTS knowledge of hydraulic & pneumatic power systems. (24017)
Be able to demonstrate PTS knowledge of electrical systems. (25020)
Be able to demonstrate PTS knowledge of aircraft inst. systems and electronics. (26049)
Be able to demonstrate PTS knowledge of fire protection systems. (27008)
Be able to demonstrate PTS knowledge of cabin environmental control systems. (28013)
Be able to demonstrate PTS knowledge of ice and rain protection systems. (29015)

Knowledge Objectives associated with Commercial Pilot TCO (Liberty University School of Aeronautics, 14 CFR Part 141 Commercial Pilot Training Course Outline, Revision 1, 23 February 2018, p. D-7-4)

Appendix C

Common Flight-Training Tasks associated with the Instrument Airplane TCO

COMMON FLIGHT-TRAINING UNIT TASKS (Expected to be Trained/Completed During Most Flight Training Units)		
Task #	**Task Title**	
1.4.1	Preflight Briefing	
1.1.2	Cockpit Organization	
7.5.4	Collision Avoidance	
1.2.1	Before Starting Engine(s) Flow and Checklist	
1.2.2	Engine Start Flow and Checklist for a Cold Engine	
1.2.3	Engine Start Flow and Checklist for a Warm Engine	
1.2.4	Engine Start Flow and Checklist for a Flooded Engine	
1.2.5	After Starting Engine(s) Flow and Checklist	
1.3.1	Taxi from the Parking Ramp to the Runway	
1.3.2	Taxi Flow and Checklist	
1.3.3	Before Takeoff Checklist	
2.1.1	Runway Flow and Checklist	
3.1.5	Vy Climb	
3.1.1	After Takeoff Flow and Checklist	
3.1.3	Enroute Climb	
3.2.13	Cruise Flow and Checklist	
3.2.3	Straight and Level Low-Speed Cruise Flight	
3.2.4	Straight and Level High-Speed Cruise Flight	
3.2.6	Normal Turn to a Heading	
3.2.13	Climbing Turn to a Heading	
3.2.14	Descending Turn to a Heading	
3.3.1	Descent Flow and Checklist	
4.1.1	Preliminary Landing Flow and Checklist	
4.2.1	Landing Flow and Checklist	
4.2.2	Normal Landing	
5.1.1	After Landing Flow and Checklist	
5.1.2	Taxi from the Runway to the Parking Ramp	
5.2.1	Parking Checklist	
5.2.2	Securing Checklist	
5.3.3	Postflight Debriefing	

Common Flight-Training Unit Tasks associated with Instrument Airplane TCO (Liberty University School of Aeronautics, 14 CFR Part 141 Instrument Airplane Training Course Outline, Revision 1, 28 August 2017, pp. C-7-3, C-7-4)

Appendix D

Common Flight-Training Unit Tasks associated with Commercial Pilot TCO (Liberty University School of Aeronautics)

COMMON FLIGHT-TRAINING UNIT TASKS (Expected to be Trained/Completed During Most Flight Training Units)	
Task #	**Task Title**
1.4.1	Preflight Briefing
1.1.2	Cockpit Organization
1.4.6	CTAF Departure Taxi Communications at a Non-Towered Airport
7.5.4	Collision Avoidance
1.2.1	Before Starting Engine(s) Flow and Checklist
1.2.2	Engine Start Flow and Checklist for a Cold Engine
1.2.3	Engine Start Flow and Checklist for a Warm Engine
1.2.4	Engine Start Flow and Checklist for a Flooded Engine
1.2.5	After Starting Engine(s) Flow and Checklist
1.3.1	Taxi from the Parking Ramp to the Runway
1.3.2	Taxi Flow and Checklist
1.3.3	Before Takeoff Checklist
2.1.1	Runway Flow and Checklist
2.3.1	Request and Comply with an ATC Takeoff Clearance
3.1.5	Vy Climb
3.1.1	After Takeoff Flow and Checklist
3.1.2	Enroute Climb in VMC
3.1.3	Enroute Climb in IMC
3.1.4	Vy Climb in VMC
3.1.5	Vy Climb in IMC
3.2.1	Straight and Level Low-Speed Cruise Flight in VMC
3.2.2	Straight and Level High-Speed Cruise Flight in VMC
3.2.5	Normal Turn to a Heading in VMC
3.2.7	Climbing Turn to a Heading in VMC
3.2.8	Descending Turn to a Heading in VMC
3.2.3	Straight and Level Low-Speed Cruise Flight
3.2.4	Straight and Level High-Speed Cruise Flight
3.2.6	Normal Turn to a Heading
3.2.13	Climbing Turn to a Heading
3.2.14	Descending Turn to a Heading
3.2.15	Cruise Flow and Checklist

COMMON FLIGHT-TRAINING UNIT TASKS (Expected to be Trained/Completed During Most Flight Training Units)	
Task #	**Task Title**
3.3.1	Descent Flow and Checklist
3.3.3	Normal Enroute Descent in VMC
3.5.2	Request and Comply with ATC Radar Flight Following
4.1.1	Preliminary Landing Flow and Checklist
4.1.2	Normal Approach
4.2.1	Landing Flow and Checklist
4.2.2	Normal Landing
4.3.4	Request and Comply with an ATC Landing Clearance
5.1.1	After Landing Flow and Checklist
5.1.2	Taxi from the Runway to the Parking Ramp
5.2.1	Parking Checklist
5.2.2	Securing Checklist
5.3.2	Request and Comply with an ATC Arrival Taxi Clearance
5.3.3	Post Flight Debriefing

Common Flight-Training Unit Tasks associated with Commercial Pilot TCO (Liberty University School of Aeronautics, 14 CFR Part 141 Commercial Pilot Training Course Outline, Revision 4, 23 February 2018, pp. C-7-4, C-7-5)

Appendix E

Host University IRB Approval Authorization Email

IRB-FY20-21-142 - Initial: Initial - Non-Human Subjects Research

irb@liberty.edu <irb@liberty.edu>
Fri 12/18/2020 9:08 AM
To: Cihak, Tony <awcihak@liberty.edu>

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

December 18, 2020

Anton Cihak

Re: IRB Application - IRB-FY20-21-142 Follow-on Student Pilot Performance Differences Based on Private Pilot Training in a Residential Collegiate Program or Non-Collegiate Program

Dear Anton Cihak,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your research with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study is not considered human subjects research for the following reason:

(1) It will not involve the collection of identifiable, private information.

Please note that this decision only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

Appendix F

FIT IRB Approval Authorization Email

Florida Institute of Technology
Institutional Review Board

Notice of Exempt Review Status
Certificate of Clearance for Human Participants Research

Principal Investigator: Anton W. Cihak II

Date: February 4, 2021

IRB Number: 21-014

Study Title: Follow-on Student Pilot Performance Differences Based on Private Pilot Training in a Residential Collegiate Program or Non-Collegiate Program

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.101, your study has been determined to be minimal risk for human subjects and exempt from 45 CFR46 federal regulations. The Exempt determination is valid indefinitely. Substantive changes to the approved exempt research must be requested and approved prior to their initiation. Investigators may request proposed changes by submitting a Revision Request form found on the IRB website.

Acceptance of this study is based on your agreement to abide by the policies and procedures of Florida Institute of Technology's Human Research Protection Program (http://web2.fit.edu/crm/irb/) and does not replace any other approvals that may be required.

All data, which may include signed consent form documents, must be retained in a secure location for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

The category for which exempt status has been determined for this protocol is as follows:

4) Research involving the **collection or study of existing data, documents, records, or specimens** if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, indirectly or through identifiers linked to the subjects.

Appendix G

Host University Flight Operations Manual: Weather Minimum Extract

LIBERTY UNIVERSITY. SCHOOL of AERONAUTICS	FLIGHT OPERATIONS MANUAL	Page: 2-3-1 Revision: 9 Date: 15 AUG 2019
	CHAPTER 2: NORMAL OPERATIONS **Section 3: Weather Minimums**	

2.1. WEATHER MINIMUMS

2.1.1. Obtaining Weather Information

A. Prior to all flights, each pilot must be familiar with the following information:

1. The current METAR.
2. The TAF forecast.
3. Radar returns.
4. SIGMETs/AIRMETs.

B. Prior to any cross-country flights, each pilot must obtain a standard weather briefing from Flight Service using one of the following methods:

1. Phone: 1-800-WX-BRIEF
2. Website: www.1800wxbrief.com

C. Additional weather information can be obtained from other sources such as www.aviationweather.gov.

2.1.2. Obtaining Notices to Airmen (NOTAMs)

A. All pilots are responsible for complying with the latest NOTAMs.

2.1.3. Weather Minimums

A. The PIC is responsible for compliance with the limitations established in this section.

B. No pilot may intentionally fly into conditions that are outside of these weather limitations, except as allowed in 2.3.4, below.

C. If weather deteriorates in flight so that flight outside of these limits is unavoidable, the PIC must choose the safest option.

2.1.4. Instrument Approach Weather Minimums

A. No pilot may initiate an instrument approach with the intention of landing if the ceiling and/or visibility are reported to be below the published minimums for that approach. RVR, when available, is controlling.

B. If the aircraft is already established past the Initial Approach Fix and the required ceiling or visibility decreases below published minimums, the pilot may continue the approach to the DA/MDA.

C. The SOF may authorize any CFII with more than 500 hours of total airplane time to conduct flight operations when the ceiling and visibility are below LUSOA IFR minimums delineated in section 2.3.6.

2.1.5. Pre-Private Students

WARNING: These limitations represent the maximum weather limitations for dual and solo flight. It is the responsibility of the instructor who authorizes the flight to ensure that the PIC has practiced and is proficient for the current and forecast weather conditions.

Type of Operation (includes night unless otherwise specified)	Maximum Surface Wind (including gusts)	Maximum Tailwind Component	Maximum Crosswind Component (including gusts)	Minimum Ceiling	Minimum Visibility
Dual Pattern	25 knots	10 knots	Demonstrated Maximum	1500' AGL	3 SM
Dual Local	25 knots	10 knots	Demonstrated Maximum	2000' AGL	5 SM
Dual XC Day	25 knots	10 knots	Demonstrated Maximum	3000' AGL	+6 SM
Dual XC Night	25 knots	10 knots	Demonstrated Maximum	3500' AGL	+6 SM
Solo Pattern	15 knots	5 knots	8 knots	2500' AGL	5 SM
Solo Local	15 knots	5 knots	8 knots	5000' AGL	+6 SM
Solo XC	15 knots	5 knots	8 knots	5000' AGL	+6 SM
Solo Night*	10 knots	5 knots	5 knots	5000' AGL	+6 SM
Dual Night IFR	25 knots	10 knots	15 knots	2000' AGL	3 SM

* Solo operations at night require DFO authorization.

2.1.6. Rated Pilots

WARNING: These limitations represent the maximum weather limitations for dual and solo flight. It is the responsibility of the instructor who authorizes the flight to ensure that the PIC has practiced and is proficient for the current and forecast weather conditions.

Type of Operation (includes night unless otherwise specified)	Maximum Surface Wind (including gusts)	Maximum Tailwind Component	Maximum Crosswind Component (including gusts)	Minimum Ceiling	Minimum Visibility
VFR Dual Pattern	25 knots	10 knots	Demonstrated Maximum	1500’ AGL	3 SM
VFR Dual Local	25 knots	10 knots	Demonstrated Maximum	2000’ AGL	5 SM
VFR Dual XC Day	25 knots	10 knots	Demonstrated Maximum	3000’ AGL	+6 SM
VFR Dual XC Night	25 knots	10 knots	Demonstrated Maximum	3500’ AGL	+6 SM
VFR Solo Pattern	20 knots	10 knots	15 knots	1500’ AGL	5 SM
VFR Solo Local	20 knots	10 knots	15 knots	3000’ AGL	+6 SM
VFR Solo XC Day	20 knots	10 knots	15 knots	3000’ AGL	+6 SM
VFR Solo XC Night	20 knots	10 knots	15 knots	5000’ AGL	+6 SM
IFR Dual Day*	25 knots	10 knots	Demonstrated Maximum	500’ AGL	2 SM
IFR Solo Day*	20 knots	10 knots	15 knots	1500’ AGL	3 SM
IFR Night*	25 knots	10 knots	15 knots	2000’ AGL	3 SM

*Exception: See paragraph 2.3.4(c) for CFII’s with more than 500 hours.

2.1.7. Icing Conditions

A. The PIC will ensure that the aircraft is completely free of ice, snow, and frost prior to engine start.

B. All aircraft surfaces viewable from the cockpit must indicate that the aircraft is still free of ice, snow, and frost prior to each takeoff.

C. Intentional flight into visible moisture is prohibited when the outside air temperature (OAT) is below +5°C.

D. Intentional flight into known icing conditions is prohibited.

2.1.8. Taxiway / Runway Conditions

A. Flight operations will cease when any of the following conditions exist:

1. More than 1/2 inch of standing water or snow.
2. Any slush.
3. Braking action reported as POOR or NIL.

2.1.9. Thunderstorms

A. Pilots must stay at least 20 miles from any severe thunderstorm (defined as tops above FL350 or identified by radar as returning intense echoes) while airborne.

B. Pilots must stay at least 10 miles from any thunderstorm while airborne.

C. Ramp activities must cease when thunderstorms are within 5 miles of the airport.

2.1.10. SIGMETS

A. Pilots may fly through an area defined by a Convective SIGMET with the permission of the DFO or the SOF on duty.

B. No pilot may fly through an area defined by any other SIGMET.

2.1.11. Operations in IMC

A. The following maneuvers and practices are prohibited in IMC:

1. Slow flight and/or stalls.
2. Unusual attitudes.
3. Simulated partial panel operations.
4. Simulated emergencies (including one-engine inoperative maneuvers and

operations).

2.1.12. Operations at Night

A. The following maneuvers are prohibited at night:

1. Ground reference maneuvers.
2. Simulated engine failures in ASEL that result in a loss of altitude.
3. Engine shutdowns in AMEL.
   a) Exception: an instructor may retard the power to simulate engine shutdown and conduct single engine approaches and landings.

B. Students are not authorized to carry passengers at night unless a LUSOA IP is onboard, seated at a pilot station.

2.1.13. Cold Weather Operations

A. First flight of the day

1. When air temperatures are below 20°F (-6°C) use an external preheater and an external power source whenever possible.
2. When air temperatures are above 20°F (-6°C), but below freezing, the PIC may request external preheat and/or external power.
3. Please ensure while waiting for preheat or de-ice that you are beside your aircraft. This will assist Line personnel in identifying aircraft requiring service and expedite the process.

> **CAUTION**: Although the 172 POH allows for turning the propeller through by hand, LUSOA has prohibited this technique.

B. Cessna 172 standby battery test.

1. If the test lamp flickers or fails to illuminate, the pilot must verify proper operation of the standby battery using the procedure in the POH section 4-47.