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about **the council**

ATEC was founded in 1961. Its mission is to promote and support aviation maintenance technical education.

The council actively engages with regulatory and legislative bodies to advocate on behalf of the community, and provides resources, continuing education, and networking opportunities for our members.

Our membership is made up of employers, vendors, and educational institutions with aviation technical programs. The vast majority of member schools are certificated by the FAA to provide aviation mechanic programs.

Membership supports the following activities and initiatives—

- Advocating for sound regulatory policy, the development of clear and concise guidance, and consistent enforcement and application
- Participating on industry and agency committees to further aviation technical education and workforce development
- Fostering and supporting career pipeline partnerships between industry and educational institutions
- Facilitating networking opportunities through the annual conference, Washington fly-in, regional outreach meetings, and virtual webinars
- Enhancing aviation technical career awareness through support of ATEC's sister organization, Choose Aerospace

about **the journal**

The *ATEC Journal* (ISSN 1068-5901) is a peer-reviewed, biannual electronic publication. The publication provides an opportunity for educators, administrators, students and industry personnel to share teaching techniques and research. Authors are encouraged to submit their articles for publication consideration, whether scholarly, research, application, or opinion, by using the submission form below. Papers supporting the council's regulatory and legislative agenda may be considered for presentation via online webinar and at the annual conference. Suggested topics include:

- Technical and soft-skills curriculum integration
- A history of legislative actions affecting aviation maintenance workforce development
- A study on implementing employer-education partnerships
- Funding implications stemming from Bureau of Labor Statistics occupational outlooks
- Highlighted innovations in the aviation maintenance industry
- A look at successful online teaching methods and subject matter in other technical fields
- Surveying currently used computer-based teaching across aviation maintenance training schools

SUBMISSION DEADLINES

Fall Issue Closing Date: October 1 • Spring Issue Closing Date: May 1

SUBMIT AN ARTICLE FOR REVIEW AT ATEC-AMT.ORG/THE-JOURNAL.HTML

from the EDITOR

The Editorial Board and I would like to extend a hearty congratulations to the ATEC community as a whole for all the hard work and dedication that has, at long last, been rewarded by the final issuance of the new Part 147. Our community will surely embrace the opportnuities presented by this new guidance and we look forward to seeing the new and innovative ways our schools and isntructors put it into practice. It is our hope that as you're working within this new framework, you will feel compelled to share your experiences with your ATEC peers by writing articles for publication in the Journal in an effort for continued collaboration.

In this issue, Christine Kelley and Robert Gallagher of Embry-Riddle Aeronautical University discuss their findings from their analysis of how COVID-19 may have affected the AMT certification testing scores across the country. We hope you find their results useful in your own classrooms and schools.

As always, I extend my gratitude to the Editorial Board for their consistant dedication and service. And to our readers, please never hesitate to reach out to any of us with any questions or suggestions you may have about how we can continue to improve on this resource to better meet the needs of our community.

Best,

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COMMITTEE UPDATES

MEETING PLANNING COMMITTEE

The long-awaited in-person conference this past March was a huge success. More aviation technical school and industry representatives joined us for the annual conference than ever before. See event photos, recorded sessions, and the attendee list at atec-amt.org/2022-annual-conference.

Plans have already begun for Chicago 2023! The Aviation Institute of Maintenance is happy to host the community at our facilities March 26-29. Look for registration to open this fall, sponsorship and exhibitor opportunities will post in the coming weeks. More information is available at atec-amt.org/annual-conference.

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MEMBERSHIP COMMITTEE

The trade association continues to grow its membership, again breaking previous records with record high membership—for the seventh year running. More than three quarters of all part 147 programs are ATEC members, meaning the council has surpassed its membership goals for the year.

This year's activities have been largely focused on implementation of the new part 147. ATEC member schools enjoy free templates and resources to help with the compliance, something nearly all of our AMTS members have already taken advantage of. ATEC will continue to seek out new ways to support its membership and welcome your feedback on how we may continue to expand our reach.

KIM PRITCHARD
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REGULATORY COMMITTEE

Committee members are overseeing the council's activities surrounding implementation of the new rule. Much is left to be done, including development of more educational webinars, providing expertise on council feedback to the FAA, and reviewing and commenting on agency guidance material.

Going to EAA AirVenture? Join us in Oshkosh on July 27 to learn more about the council's work in this area and provide your feedback! An ATEC Outreach meeting—sponsored by Bombardier and the Flying Classroom—will start with a brief on the new rule and end with dessert and a great view of the evening air show. Register at atec-amt.org/outreach-meetings.

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CHOOSE AEROSPACE, INC.

The Choose Aerospace general aviation maintenance curriculum went through a very successful pilot test this year, with ten programs and 250 students participating. Special thanks to all the education and industry representatives that contributed to the advisory committee to help us ensure the curriculum is a world-class resource available to support AMTS pathway programs into high schools and community-based organizations.

Applications are open to adopt the curriculum for the 2022-2023 academic year. So far, 12 schools have committed 400 student enrollments—these are students that have been given the opportunity to Choose Aerospace when it was not previously available. We expect these students to join ranks as non-certificated technicians, matriculate into part 147 schools, and enter apprenticeship programs in the coming years, and is something we are very proud of.

Learn more at chooseaerospace.org/curriculum.

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COMMITTEE UPDATES

LEGISLATIVE COMMITTEE

After years of advocacy work and engagement with our legislative leaders, the community is finally reaping the benefits—the new part 147 will go into effect on Sept. 21. The committee is continuing to engage with Congress to ensure implementation aligns with congressional intent and making plans for the council's next order of business as FAA reauthorization approaches.

Where else would you be on Sept. 21 but in Washington? Join us for the Washington Fly-in on the Part 147 Effective Date in celebration of the first day of a new approach to aviation technical education. FAA and other government officials will join us to talk about implementation and new opportunities available for workforce development. Stakeholders will then convene on Capitol Hill to engage with lawmakers on aviation workforce priorities.

Educators, administrators, career placement personnel, advocates, and industry recruitment and training representatives are all invited to join us in celebration of what we have achieved and commit to the work that still needs to be done.

Register to attend at atec-amt.org/fly-in.

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A New Way of Teaching Future Aviation Mechanics is Here

By **Crystal Maguire,**
Executive Director, ATEC

After more than a decade of advocacy by industry stakeholders, the FAA has promulgated a new part 147—the regulation governing aviation maintenance technician schools. The new rule goes into effect on Sept. 21, 2022 and will usher in a new approach to aviation technical training, one that provides more freedom and flexibility for educators and their industry partners.

The new rule is in line with congressional mandate originating on Dec. 12, 2019 with introduction of the Promoting Aviation Regulations for Technical Training (PARTT) 147 Act (S.3043/H.R.5427). The legislative language—drafted and orchestrated by ATEC—received broad industry support and was championed by Sens. Jim Inhofe (R-Okla.) and Tammy Duckworth (D-Ill.), the late Don Young (R-Alaska), and Rep. Cheri Bustos (D-Ill.).

On Dec. 27, 2020, the congressional directive mandating removal and replacement of part 147 was signed into law as part of the massive coronavirus relief package, the Consolidated Appropriations Act, 2021 (H.R.133/Public Law 116-260).

The new rule introduces a performance-based regulation that will massively change the way FAA approves and oversees aviation technical programs.

Under the new rule, for nationally accredited programs, the FAA will defer to Department of Education accreditors in all areas concerning quality of education, meaning the agency will no longer approve curriculums, methods of instructional delivery (i.e., no more FAA distance learning authorizations required), how and where educational content is consumed (i.e., schools will have the opportunity to provide training at an additional fixed location, such as a high school), grading systems, testing schedules, or class sizes. And under the watchful eye of national accrediting bodies, AMTS will assess educational outcomes in lieu of meeting seat time mandates—aligning aviation maintenance education with common practice in other technical-related programs.

As part of the part 147 certification requirements, the FAA will continue to oversee a program's facilities, equipment, and instructor qualifications, control the certification standards (i.e., mechanic airman certification standards) that drive school curriculums, and continually assess AMTS performance through analysis of student passage rates. And most importantly for aviation safety, the FAA will retain the ultimate decision-making authority when it comes to issuing mechanic certificates, which it only does after thorough assessment of an individual's skill and knowledge.

Since the new rule was promulgated on March 24, ATEC has hosted weekly webinars with FAA officials and released a host of resources and events to support the transition. Previously-recorded briefings available to all stakeholders include—

- The New Part 147: An Overview
- The Next 120 Days: A Checklist
- Aligning Curriculum to the ACS: New 147.17 Training Requirements
- Opportunity Awaits: New 147.15 Training Provided at Another Location
- Accreditor Deference: New 147.23 Quality Control Systems
- A Quality Check: New 147.25 Minimum Passage Rate
- Mechanic Testing Under the New ACS
- Getting Creative: Creating Content to Address New ACS Elements
- Curriculum Changes: Best Practices for Addressing New Training Requirements
- Two-Week Countdown: Are You Ready for the New Part 147

Also available are templates for non-accredited institutions requiring quality system approvals, and documents for AMTS to request new operations specifications from their local office by the Sept. 21 deadline.

For more information including the text of the rule and guidance material, previously recorded and upcoming webinars, and resources available to the community, visit the The New Part 147 landing page.

Exploratory Analysis of COVID-19 Impact on AMT Part 147 Schools' AMG, AMA, & AMP Certification Exam Test Scores

BY **CHRISTINE KELLEY**

Christine Kelley has worked at Lockheed Martin for over twenty years in both design engineering and IT. She has a Bachelor of Science in Mechanical Engineering from Texas Tech University, a Master of Science in Technical Management from Embry-Riddle University, and is currently a Ph.D. candidate at Embry-Riddle in Aviation Business Management.

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Robert Gallagher has over fifty years in aviation, holds an A&P license, and graduated from a 14 CFR Part 147 school. He has instructed at a Part 147 school, as well as been a technical instructor at the airlines and MROs. He has a Bachelor of Science in Education and a Master of Business Administration in Aviation Management. He is currently a Ph.D. candidate at Embry-Riddle in Aviation Business Management.

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ABSTRACT

The FAA identifies and mandates under title 14 of the *Code of Federal Regulations* (CFR), Part 65 Subpart D, section 65.75 knowledge that an applicant for a mechanics certificate must possess. The knowledge-based tests, more commonly referred to as the "written" examinations, covers materials specific to either an airframe certificate (AMA) or a powerplant certificate (AMP) with the general (AMG) component being common to each. The prescribed level of testing for a Part 147 school is specifically outlined under §147.38a Quality of Instruction and measured by the results of the Knowledge Based Test (KBT) examinations for all students tested against a national standard. During the COVID pandemic, approved institutions faced training and learning challenges. This paper investigates standardized national norm scores at a pre-pandemic level compared to test results during the actual pandemic using data from first quarter 2015 to current. Data gathered from the FAA Form 8080-08 was reviewed, analyzed, and stratified by institution type, regions, number of applicants, year and pandemic or non-pandemic. A noticeable drop in average test grades was observed in each of the three testing regimes, AMG, AMA, and AMP. This paper explores if the analyzed variables affect the test scores, and if so, to what degree. This helps advance the field by assessing if average test graduates were affected by the COVID-19 pandemic.

Key Words

Aviation Maintenance Technician, AMT, FAA Mechanic, FAA Form 8080-08, Knowledge Requirements, Part 147, Airframe, Powerplant, Testing, Pandemic

INTRODUCTION

Aviation maintenance is a highly skilled and heavily regulated environment throughout the world. This degree of heavy regulation ensures the traveling public's safety. According to the International Civil Aviation Organization (ICAO), the roles of the aircraft maintenance engineer (AME) and aviation maintenance technician (AMT) are critical to maintaining the safety of commercial air travel. Not only does the AMT or engineer maintain, repair, inspect and overhaul the aircraft, they also ensure continuous airworthiness of the product. The AMTs are responsible for ensuring airworthiness over the entire life of the aircraft.

As new aircraft continue to enter the marketplace, the demand for qualified personnel continues to expand worldwide. As explained by van der Heiden, et al. (2015) there is a need for both education and training within a high value-added aerospace industry. Most AMTs in the United States enter the occupation by attending FAA-approved 14 CFR Part 147 institutions. According to U.S Government Accountability Office data, 62 percent of students use this route to certification. Within that is a vast array of training institutions including both 2- and 4-year colleges that offer degrees and management classes both in the public and private sectors. Additionally, some institutes solely offer specific vocational or occupational classes with the goal of making the student complete the coursework and exams. Because no minimum educational entry requirement exists to become certificated, some programs are offered through public high schools. These programs allow applicants to be eligible for examination upon their graduation from such schools. In a 2002 launch of a new program at Embry-Riddle Aeronautical University (ERAU), it was stated that there is an annual need for 10,000 new certificated AMTs, but the normal product of the 14 CFR Part 147 schools is about 6,000 per year (Moore, P 2002, 08). This leaves an annual shortage. Forecasts in 2018 by Mohawk Valley Community College predicted approximately 135,000 openings for certified mechanics during the next 20 years (McChesney, C., 2018).

Although a shortage was already forecasted, the onslaught of COVID-19 on the global community has yet to be understood. However, in the late winter of 2020, the pandemic had spread throughout the globe causing a shutdown, requiring an unprecedented storage of the worldwide aircraft fleet. Early in the COVID-19 pandemic, the International Air Transport Association forecasted the risk of approximately 25 million aviation related jobs on a worldwide basis (Press Release No. 28 dated April 7, 2020). On September 21, 2021, Airlines for America, the US- based trade organization, delivered its *Emerging from the Pandemic* report (see Table 1 below) in which the below data was released to the industry showing substantial job losses to the industry in the United States. The data also indicates that while US-based carriers are seeing increases in air travel, they will probably not see the levels climb to the pre-pandemic volumes until 2023.

Table 1: Airline industry impacts.

Carrier Universe	Scheduled U.S. Passenger Airlines	All U.S. Passenger and Cargo Airlines
Measure	FTEs (000)	Headcount (000)
All-Time High	June 2001: 545.9	May 2001: 760.8
Post-2000 Low Point	April 2010: 376.7	April 2010: 562.3
Pre-Covid Peak	Feb 2020: 458.2	Feb 2020: 753.4
Latest Available Data Point	July 2021: 402.6	July 2021: 715.3

Recreated from *Emerging from the Pandemic*, 2021

In the years leading up to the pandemic, the industry experienced record growth with new aircraft being delivered to the market. During this time, the ATEC 2018 *Pipeline Report* (Aviation Technician Education Council, 2018) predicted 30 percent of AMT's were approaching retirement age. The industry cited hiring initiatives that were falling short according to AviationPros.com (Facing the Maintenance Skills Shortage, 2019), which also forecasted the need for 198,000 new mechanics by 2037. Mechanics are also needed for new aircraft production. Boeing sold approximately 340 aircraft to airlines in 2021, 157 in 2020, and 806 aircraft in 2018 while Airbus delivered 611 jets in 2021. (Pfeifer, S., & Bushey, C., 2022). A forecast from Boeing estimated a global demand for 626,000 new technicians in commercial aviation through 2040 (Boeing, 2020).

According to title 14 of the *Code of Federal Regulations* (CFR) Part 147, curriculum requirements must be met for the issuance of a certificate on the part of the school or training institute. To train a student to become an AMT, the following FAA requirements in 14 CFR Part 147 schools must be met. A minimum of the following contact hours must be included into the program curricula:

General:	400
Airframe:	750
Powerplant:	750
Total:	1,900

These hours equal 38 hours per week, 50 weeks a year to complete a course. At that time, the student would become eligible to sit for the prescribed series of exams. Prospective students, given the forecasts and industry shutdown, would have begun making decisions as to the viability of such programs and prospective employment opportunities. Additionally, concerns within the education community would have been evaluated for the survivability and viability of such programs. The FAA also dictates the quality of the instruction received under 14 CFR Part 147 by tracking and mandating that success (passing with a minimum of 70 percent) on the student's first attempt be within defined standards as it relates to the "national passing norm." Failure to comply with the quality standard could require the institution to receive additional federal oversight and program review.

With the industry already under-staffed, demand rising, and the demand for global air travel recovering, the researchers wanted to investigate if the quality of education delivered by the 14 CFR Part 147 schools and the success rate of the prospective AMT applicants was affected by the pandemic.

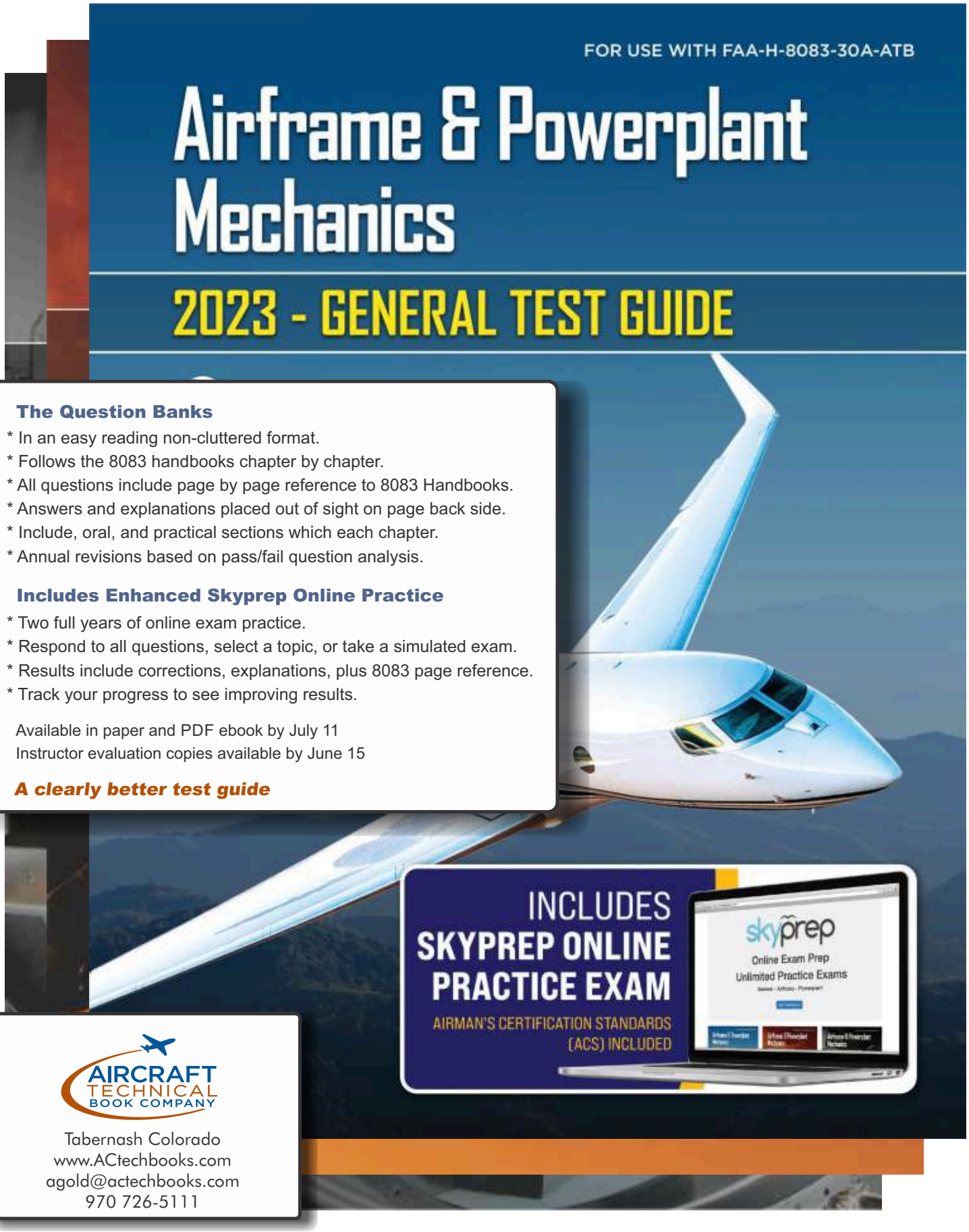
To examine this question, the researchers analyzed FAA data contained in the FAA Form 8088-8 related to the success of prospective AMT applicants graduating from each of the 14 CFR Part 147 schools. The FAA collects this data quarterly for each school and categorizes into each of the three examinations (General, Airframe, and Powerplant). The data is further broken down by schools and compared to a national norm rate with a base of 70 percent passing or success rate. As a normalizing process, data was reviewed beginning in 2015 when the industry was functioning at a normal growth rate giving a 5-year window pre-pandemic. This data was collected and compared to the data beginning in the first quarter of 2020 and analyzed over a 5-quarter period. The findings are described more comprehensively in this paper.

This is critical because schools are rated, inspected, and required to perform to a status as identified by the applicable regulations. Changes in material and curriculum delivery might affect both the success of a school and its viability to continue as a sound business practice. The success of graduates is a measurement of viability.

LITERATURE REVIEW

A common and regulatory thread that ties together all the institutions investigated is that they all must comply with the regulatory requirements to teach and maintain a standard codified in 14 CFR. As such, success in the teaching and testing of critical material for the issuance of an FAA AMT certification by the federal authorities (the license/certificate) is required. Maintenance certificates are relinquished in only three ways: suspension, surrender or revocation by the issuing authority (the FAA). Most would associate the testing outcomes of individuals examined to produce a correlation to the training programs in which they attended (McGuire & Gubbins, 2010).

The former FAA Administrator (O'Brien, 1990) mentioned that certification education was becoming "teaching to a test." During this period, the FAA published all the knowledge-based test (KBT) questions and answers in the public realm. That process has changed over time, and the FAA no longer publishes the KBT testing questions. However, many public companies such as Jeppesen and ASA do publish study guides that parallel the test questions. These are gleamed from previous test takers and no longer from FAA public information.


FOR USE WITH FAA-H-8083-30A-ATB
Airframe & Powerplant Mechanics
2023 - GENERAL TEST GUIDE
The Question Banks
* In an easy reading non-cluttered format.
* Follows the 8083 handbooks chapter by chapter.
* All questions include page by page reference to 8083 Handbooks.
* Answers and explanations placed out of sight on page back side.
* Include, oral, and practical sections which each chapter.
* Annual revisions based on pass/fail question analysis.
Includes Enhanced Skyprep Online Practice
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Walter (2000) concludes that "implementing training systems that develop knowledge and skills among operational personnel consistent with organizational objectives and operating procedures that are compatible with human capabilities and limitations is fundamental to reducing maintenance error." This fact draws a direct linkage between both knowledge and action; no longer can the mechanic or technician just be a parts changer. Replacement of parts without sufficient intellectual troubleshooting of a system can produce economic disaster and affect safety margins.

The training process for certification of European technicians is similar to the US approach. In this system, the basic training course consists of knowledge training, knowledge examination, practical training, and a practical assessment, showing relevance to the knowledge as well as the practical component in certification (Dilkilic, 2017). A similar view is expressed by Terry Michmerhuizen, Assistant Professor with Western Michigan University's College of Aviation. He stated at the EAA's 2012 Air Venture that AMTs need to learn and embrace non-technical skills such as the four Cs: critical thinking skills; concern for quality and integrity; comprehension of the effects of human factors on their work; and clear ability to communicate. This also points to more areas that an AMT needs to understand as opposed to just replacing parts, the knowledge is a large factor in current needs.

Williams & Rhoades (2005) contend that normal aviation maintenance technician schools (AMTSs) exceed the minimum of curricula contact hours by an average of 116 hours. This increased contact hours shows how schools' endeavor to provide more learning experiences to students to move them to higher levels of success, yet the current analysis shows differently. Currently, according to AW&ST the FAA is scrutinized for delaying a proposed change to the current rules initiated by the Aircraft Certification, Safety and Accountability Act ("Curriculum Crunch," 2021). This change was due in March 2021 but is now delayed well into the second quarter of 2022. However, it is unclear if this change will affect the down-sloping trend for grades that is currently seen.

The mechanics' responsibility is to replace parts, troubleshoot systems, isolate faults by following the fault isolation manual and restore the system to an airworthiness condition (Kinnison & Siddiqui, 2013). While it appears that part removal and replacement is the typical AMT's role, there more sophisticated functions of maintenance. However, is the system primarily producing parts-changers?

Baghdasarin, (2020) states that information literacy is the ability to assess digital (Web-based) data and is a critical skill for those involved in processing airplane health data. Such a statement is viewed as correct and an applicable position because the current state of aircraft maintenance requires such aptitude. Yet Baghdasarin

(2020) also states Generation Z and Millennial cohorts tend to fall into different learning categories because of their involvement and growth around the Internet. How do students interact and earn understanding as they memorize facts like, "What is the speed of sound on a standard day?" when they must first understand the definition of a "standard day" before determining speed.

The KBT is a comprehensive examination of the student's ability to answer multiple choice questions corresponding to each of the subject based areas of 14 CFR Part 147 curriculum. The test questions are objective-based, and a student must select the correct response for each of the questions to maintain a minimum of 70 percent, the passing criteria. Table 2 below shows the detailed requirements for each test.

Table 2: Test details.

KBT test	Total questions	Elapsed time (mins.)	Correct responses
General	60	120	42
Airframe	100	120	70
Powerplant	100	120	70
Average	31.93	35.24	24.51

This test is structured to show the students' mastery of the subject matter and demonstrate their ability to communicate by use of the written word. This shows both the aptitude of the test taker to understand written instructions (i.e., a technical or maintenance manual, the directions to properly service and maintain an aircraft) and their ability to communicate using written language (correct response to the question). This type of test is an additional method employed to ensure that the student complies with section 65.71 eligibility requirements. The requirements are "be able to read, write, speak, and understand the English language," or in the case of an applicant who does not meet this requirement and who is employed outside of the United States by a U.S. air carrier, have his certificate endorsed "Valid only outside the United States." This is also verified when an applicant presents themselves to the local flight standards district office (FSDO) for authorization. This is not required for those graduating from a 14 CFR Part 147 curriculum AMTS.

Current FAA information shows that Airman Certification Standards (ACS) for General, Airframe and Powerplant examinations are under development with no current proposed release date (FAA-S-ACS-1).

Hu et al. (2016) find that select preclinical course work might be a strong predictor of standard exam scores. Most have correlated AMT certification with that of medical and nursing professionals because of the regimented testing involving written, oral, and practical exams to a similar paradigm in health care licensing/certification. Swanson and Roberts (2015) state that "The purpose of licensure is to ensure that doctors have the knowledge and skills necessary to practice medicine safely and effectively." Similarly, the FAA's certification procedures parallel training for technical fields in medicine by assuring individuals have the knowledge to facilitate safe air travel using different levels of training. Swanson and Roberts further conclude that the important issue for regulators is the need to reassure the public that applicants meet a minimum level of competence, like the FAA's goals.

Problem Definition

The problem investigated was to evaluate if the grades for all three series of the FAA knowledge-based maintenance technician examinations were affected during the COVID-19 pandemic in the United States. The researchers hypothesized that the pandemic caused the grades to drop for each of the three tests.

The authors considered that there was a shift in educational delivery because educational institutions were required to reduce face-to-face teaching hours. This forced institutions to develop alternative ways to deliver required content to students. The hypothesis predicts that these changes in the educational system would have a statistically significant negative effect on the grades of qualifying exams. With the onset of the pandemic, researchers wondered if various changes to educational content and delivery programs would affect grade levels in AMT education as compared to the historical national norms. As pointed out by Dyen (2017) only two schools in the US had FAA authorization to conduct distance learning by use of either asynchronous or synchronous distance delivery. The changes that occurred were a new method to student and instructor alike with limited or no real planning, beta testing or understanding of the delivery requirements. Some schools used online lectures, an instructor speaking and students listening to a video without interactivity; others chose canned programs; and still others developed full use of technologies such as Canvas and Blackboard. Each of these had their own challenges for both student and faculty. Thus, both student and instructor entered a challenging time of technical learning and adaptation.

METHODOLOGY

All Tests (AMA, AMP, AMG)

Schools that report metrics to the FAA did so quarterly and yearly. For this paper, report FAA Form 8080-08 data was taken from the FAA's website for the quarterly reports for the years 2015 (5 years proceeding COVID-19 and the 6 quarters during the pandemic 1Q2020-2Q2021). Within the quarterly reports, there are also columns that show 2 yearly metrics as well (2-year averages for smoothing of data), these data were not included in the study. Once the quarterly pdf's were downloaded from the website, they were converted into Microsoft Excel files and all pages merged into one large file. The columns of data in that file were reduced to only those that the researchers wanted to address in this paper: School, Region, City, Number of applicants, Type of test, Number of applicants passed, Average Grade for the Quarter, and the corresponding Year. Reports were gathered from 2015 first quarter to 2021 second quar-

ter. Those records that did not have a grade reported for the quarter were filtered out of the dataset.

Once the data was combined into one dataset with all quarters from 2015 through 2021 showing the desired variables, some descriptive analysis was executed. The first research question to address was, has the pandemic affected the overall grades for the mechanic testing? The first step in the analysis was to investigate the average grade per institution per quarter for pre-pandemic and during the pandemic to see if there appeared to be a difference. Figure 1 below shows all test grades before the pandemic (in blue) and during the pandemic (in orange). The horizontal axis is the quantity of tests,

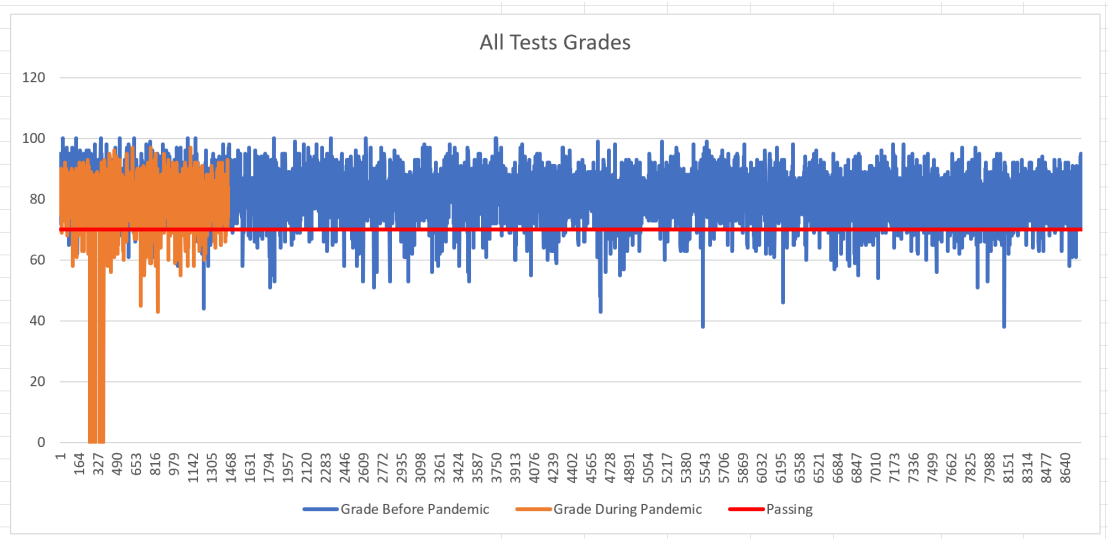

Figure 1: All test grades pre-pandemic and during pandemic versus quantity of tests.

overlaying those taken during the pandemic with those taken before COVID-19. The red line is drawn at the passing grade of 70. The figure allowed the researchers a visual indication that the grades potentially were lower during the pandemic. To further investigate this, a t-test was run.

To determine if the all grades during the pandemic were statistically different than all grades before the pandemic a t-test was run. The test was an independent t-test with the hypothesized mean difference equal to zero. The result of this test showed a two tailed p-value of .001 with a significance of .05. Therefore, the researchers realized that there was a significant difference between the means of tests groups. Because the t-test forces the sample size to be equal, 1449 tests were taken during the pandemic, so the grades were sorted by date and the last 1449 tests taken before the pandemic started were used in comparison to the pandemic grades. One point to note, as seen in the graph above, there were several zeros recorded during the pandemic while there were none recorded before. The researchers are not aware of the reasons these zeros occurred when none had been recorded before. However, they certainly effected the raw data analysis.

The results of this t-test indicated to the researchers that there is a statistically different grade average between the tests that were taken before the pandemic and after (Q2 2020 through Q2 2021). This result led to investigation of which researched variables contributed to this statistical difference.

Individual Tests

The next step in the analysis was to analyze the overall test grades of all three categories: Aviation Maintenance Technician Powerplant (AMP), Aviation Maintenance Technician Airframe (AMA), and Aviation Maintenance Technician General (AMG). This was done to evaluate their average test grades.

First, a single ANOVA of all test groups was run. The single ANOVA included data for pre/during pandemic grades for all three test types. The single ANOVA returned a p-value of 9 E-40, which is well below the significant value of .05. Therefore, the researchers knew that the average test grades were not the same. As a post-hoc evaluation, a Tukey's range test was run for the three groupings of interest: pre/during AMP, pre/during AMA, pre/during AMG. The absolute mean difference respectively is 1.2, 3.7, 2.6 while the critical q value was .26. This indicated to the researchers that there was a statistical difference between each test category from before the pandemic and during the pandemic.

With all these initial tests indicating a difference in average test scores pre/during pandemic, the researchers were interested in a deeper analysis. While the differences in average grades is not large, a few points on a hundred-point scale, it is interesting that the grades dropped at all. It would be concerning if this grade drop was indicative of future grades and results continue to drop as the pandemic rages on. To determine this, further investigation was conducted.

Descriptive Analysis

To understand the effects of variables on the average grade, three subsets of data were analyzed. Each test (AMA, AMG, AMP) was evaluated separately. For each test data set, a mixture of variables was evaluated in the study. These variables were the Number of applicants, Region, School Type, Pandemic (Pre/During), and Year. For each variable, graphs were created to represent the effect of that variable on the average grade.

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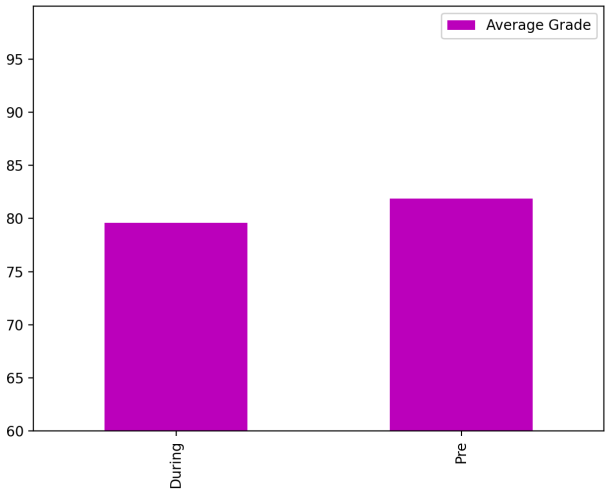


Figure 2: AMA Pandemic versus pre-pandemic grades.

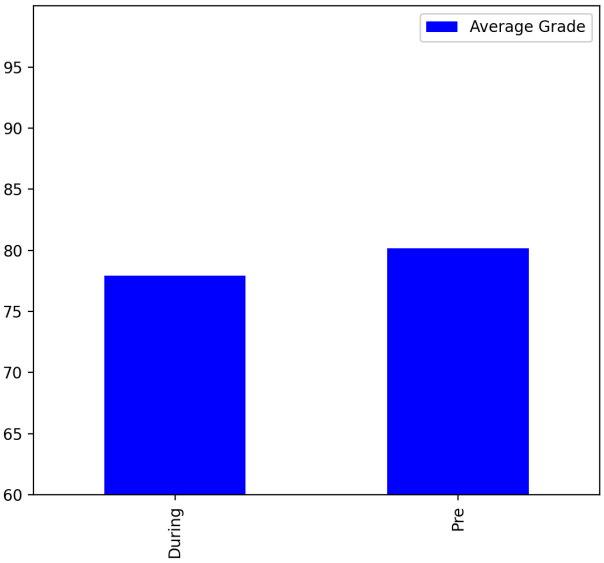


Figure 3: AMG Pandemic versus pre-pandemic. grades.

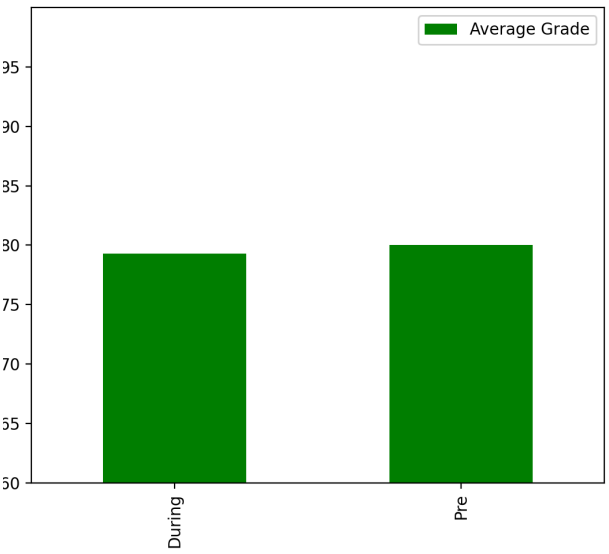


Figure 4: AMP Pandemic versus pre-pandemic grades .

Pandemic (Pre/During):

For this variable, if the test was taken before the second quarter of 2020, it was categorized as "Pre." If the test was taken during or after second quarter of 2020, it was categorized as "During." This allowed the researchers to compare very directly if the grades before and during the pandemic were the same. For each test type, test grades taken during the pandemic were lower than those taken before the pandemic. For the AMP test, the grade drop is very slight; however, it is present. The other two tests have a more significant drop in grade as shown in the below graphs.

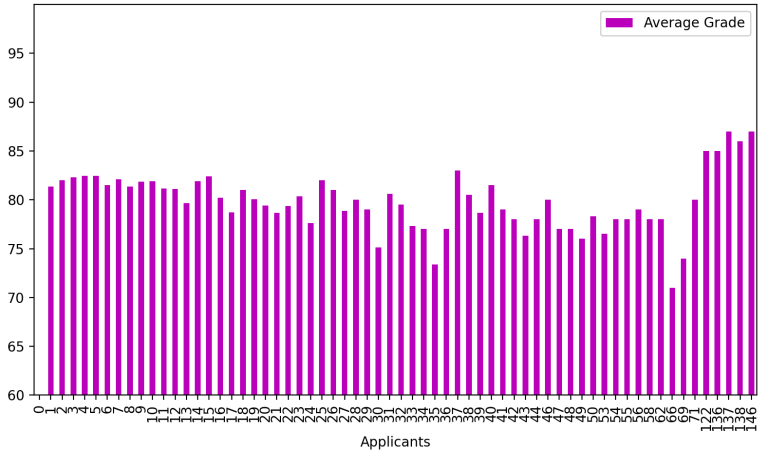


Figure 5: AMA Average grades versus number of applicants per school.

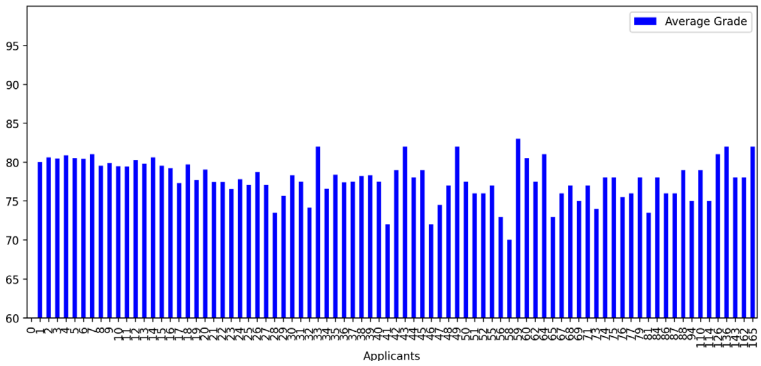


Figure 6: AMG Average grades versus number of applicants per school.

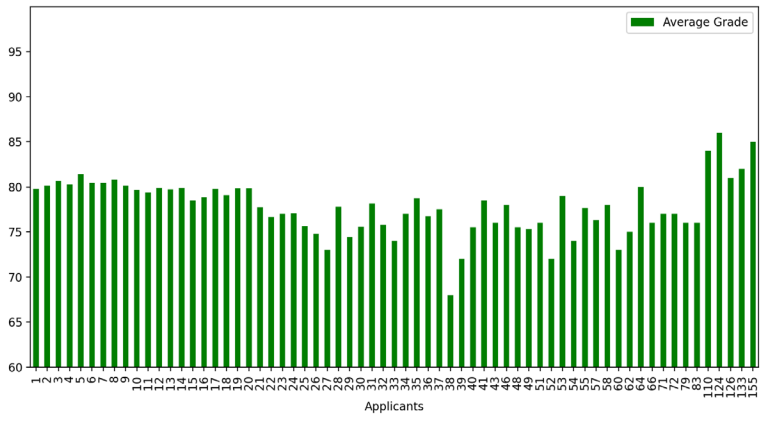
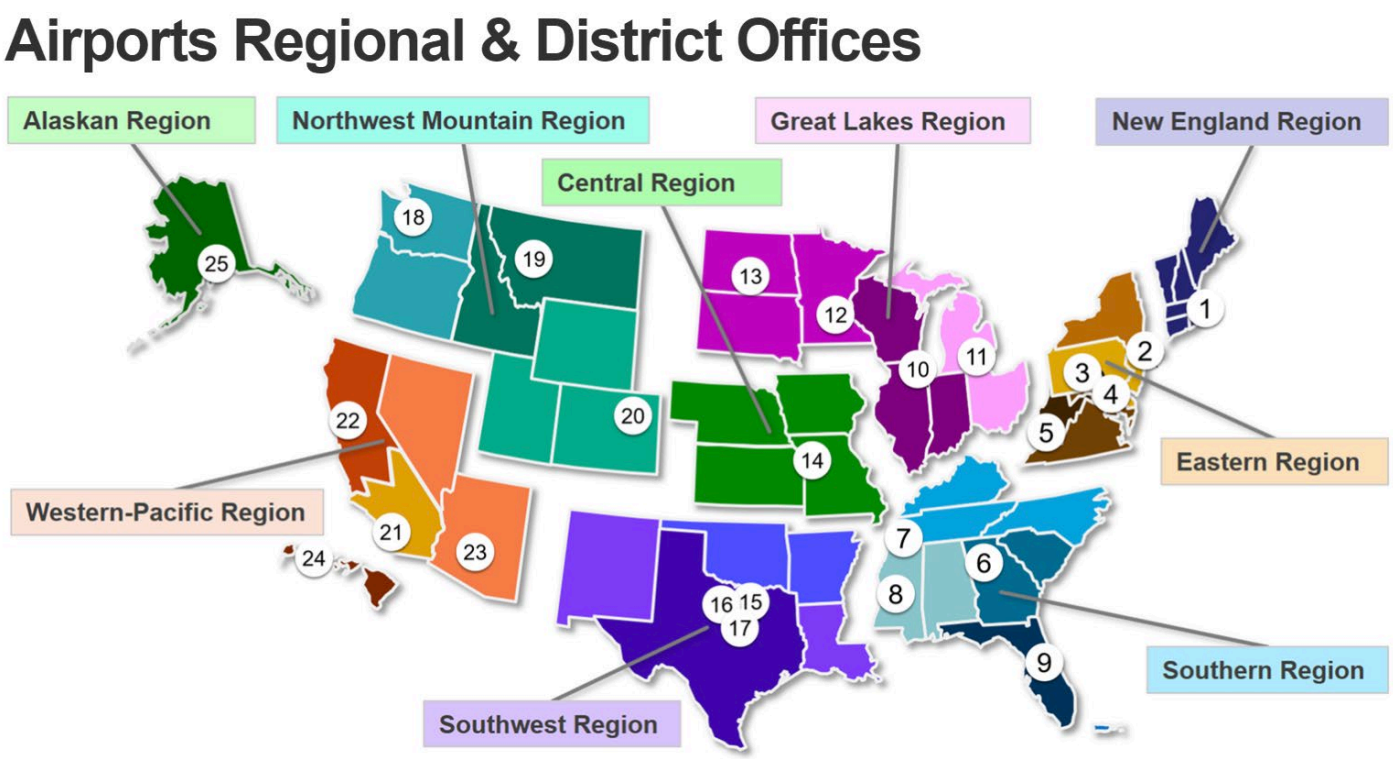


Figure 7: AMP Average grades versus number of applicants.

The next variable studied was the number of applicants per quarter taking the test at a school. The researchers wondered if class size could affect the average test grade. For the AMA and AMP tests, it appears that the greatest number of applicants yielded the highest grades. The AMG test does not appear to affect the average grade based on the number of applicants.

The third variable analyzed is region. The United States is divided into regions according to the FAA. These regions consist of: Alaskan, Central, Eastern, Great Lakes, New England, Northwest Mountain, Southern, Southwest, and Western-Pacific. These are shown on the map below.



- **Alaskan** (AK) [25]
- **Central** (IA, KS, MO, NE) [14]
- **Eastern** (DC, DE, MD, NJ, NY, PA, VA, WV) [2]
  - Beckley ADO (WV) [5]
  - Harrisburg ADO (DE, NJ, PA) [3]
  - New York ADO (NY) [2]
  - Washington ADO (DC, MD, VA) [4]
- **Great Lakes** (IL, IN, MI, MN, ND, OH, SD, WI) [10]
  - Chicago ADO (IL, IN, WI) [10]
  - Detroit ADO (MI, OH) [11]
  - Dakota / Minnesota ADO (MN,ND,SD) [12, 13]
- **New England** (CT, ME, MA, NH, RI, VT) [1]
- **Northwest Mountain** (CO, ID, MT, OR, UT, WA, WY) [18]
  - Denver ADO (CO, UT, WY) [20]
  - Helena ADO (ID, MT) [19]
  - Seattle ADO (OR, WA) [18]
- **Southern** (AL, FL, GA, KY, MS, NC, PR, SC, TN, VI) [6]
  - Atlanta ADO (GA, SC, PR, VI) [6]
  - Jackson ADO (AL, MS) [8]
  - Memphis ADO (KY, NC, TN) [7]
  - Orlando ADO (FL) [9]
- **Southwest** (AR, LA, NM, OK, TX) [15]
  - Arkansas/Oklahoma ADO [16]
  - Louisiana/New Mexico ADO [17]
  - Texas ADO [15]
- **Western-Pacific** (AZ, CA, HI, NV, GU, AS, MH) [21]
  - Honolulu ADO (HI, GU, AS, MH) [24]
  - Los Angeles ADO (Southern CA) [21]
  - San Francisco ADO (Northern CA) [22]
  - Phoenix ADO (AZ, NV) [23]
  - California Counties by Airports District Office

Figure 8: Regions as defined by the FAA.

Based on the graphs, it appears that the Alaskan, Northwest Mountain and Western-Pacific regions have produced the highest average grades for all tests over the entire testing period. These graphs are shown below.

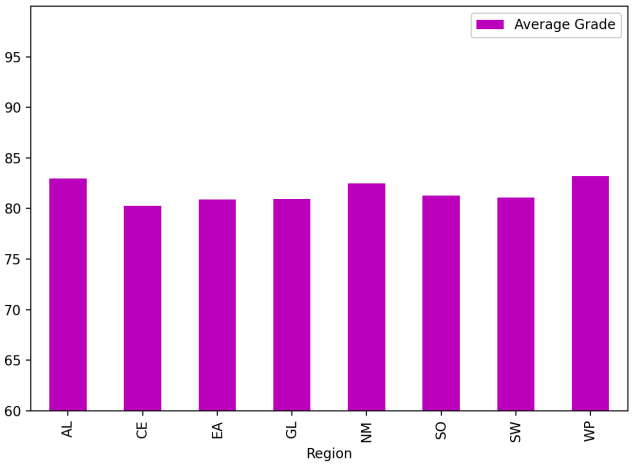


Figure 9: Average grades versus region.

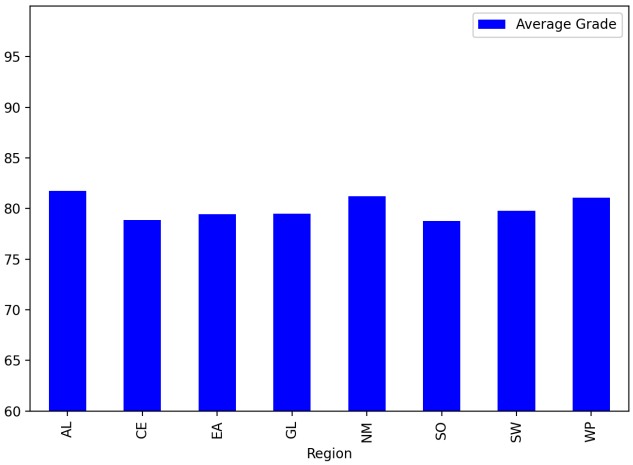


Figure 10: AMG Average grades versus region.

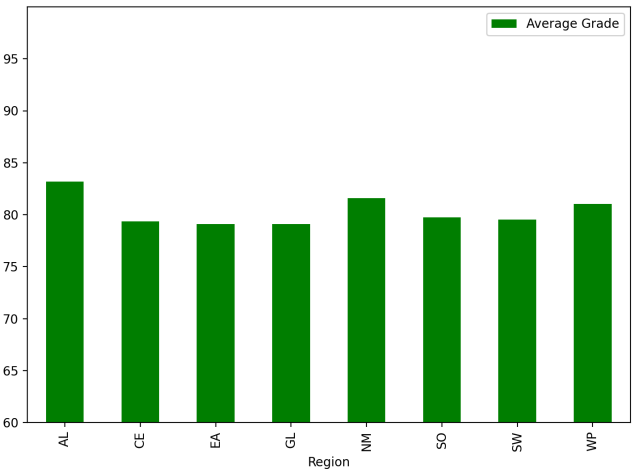


Figure 11: AMP Average grades versus region.

The fourth variable assessed is the type of school testing the applicants. The school types were divided into five categories: University, Community College, Technical School, High School, and College. Of these, it appears that the universities had consistently higher average grades than other school types. The graphs for each test type are shown below.

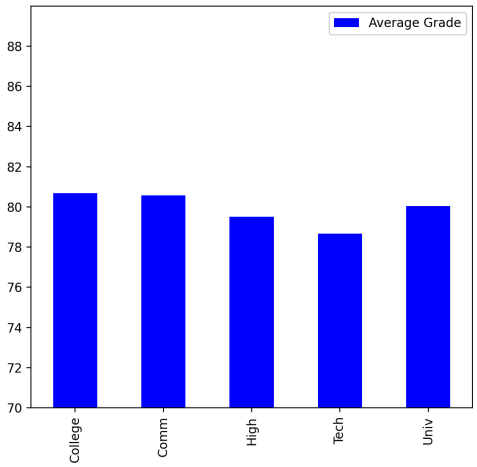


Figure 12: AMG Average grades versus school type.

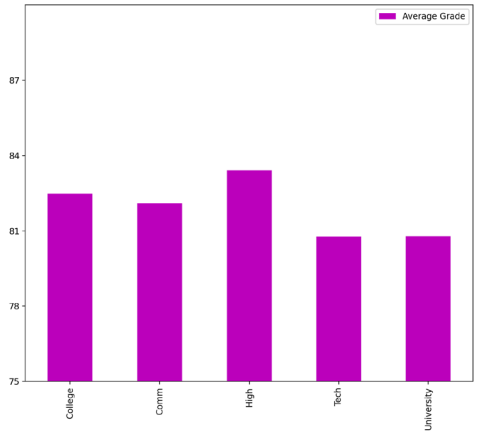


Figure 13: AMA Average grades versus school type.

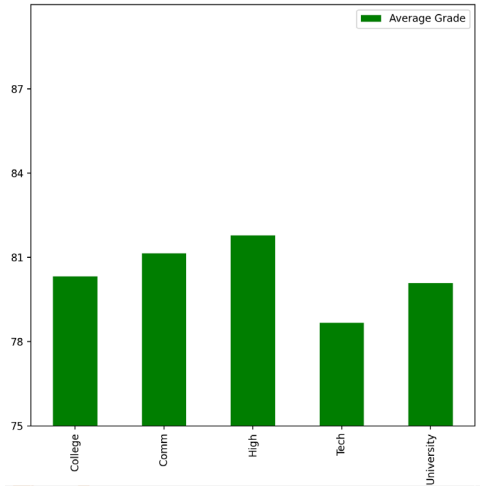


Figure 14: AMP Average grades versus school type.

The fifth and final variable analyzed for effects on average test scores is the year in which the test was taken. This graph raised questions for the researchers because it indicated that the grades in all tests were beginning to trend down before the pandemic, but certainly kept a downward slope since.

After completing the descriptive statistics, a few trends were beginning to emerge. Grades were lower during the pandemic for all tests, although not dramatically. For two of the tests, a high number of applicants in the testing class yielded visibly higher test averages. Three of the regions (Alaska, Northwest Mountain, and Western Pacific) have consistently higher grades. All three tests received the highest grades in high school than any other institution type. Last, average grades for all tests were beginning to fall before the pandemic began, around 2017. Further investigation and regression models were determined necessary.

The below chart shows a combined composite of all scores, AMG, AMA, and AMP pointing to the fact that the trend lines all went down beginning at the same time at various levels of degrees.

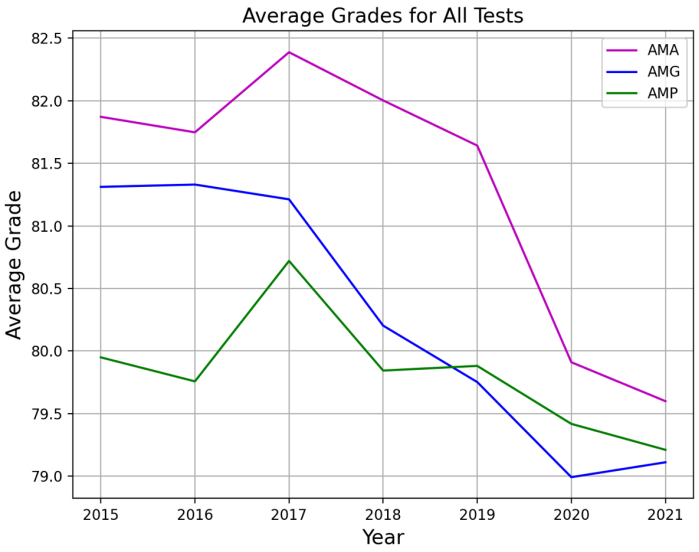


Figure 15: All tests grades over time.

Regression modeling

Once the descriptive statistics were completed, regression modeling was done. Four different types of modeling were performed to improve the chances of understanding the situation. First, singular regression was executed in Python. The independent variable of average grade was regressed against year, as the researchers were most curious about the grades decreasing over time. The results are shown below.

OLS Regression Results

Dep. Variable:	Average Grade	R-squared:	0.018
Model:	OLS	Adj. R-squared:	0.018
Method:	Least Squares	F-statistic:	102.9
Date:	Sat, 16 Oct 2021	Prob (F-statistic):	5.59e-24
Time:	12:46:19	Log-Likelihood:	-18695.
No. Observations:	5609	AIC:	3.739e+04
Df Residuals:	5607	BIC:	3.741e+04
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1083.0312	98.827	10.959	0.000	889.293	1276.770
Year	-0.4969	0.049	-10.145	0.000	-0.593	-0.401

Omnibus:	2200.701	Durbin-Watson:	2.023
Prob(Omnibus):	0.000	Jarque-Bera (JB):	33826.881
Skew:	-1.457	Prob(JB):	0.00
Kurtosis:	14.673	Cond. No.	2.20e+06

Figure 16: Single regression of average grade versus year.

Figure 17: Graph of year versus grade.

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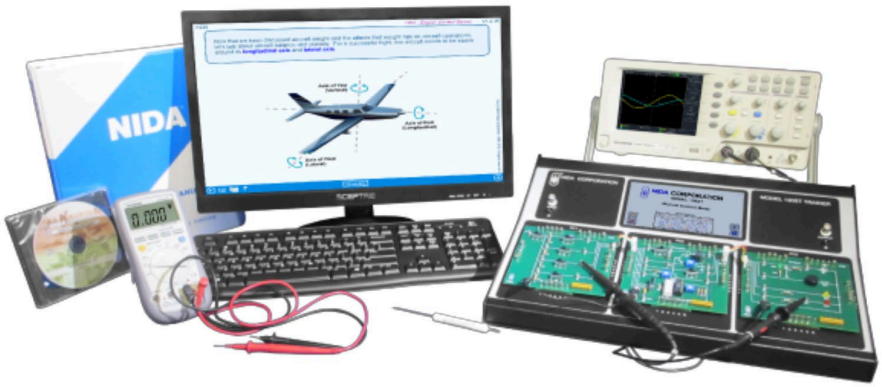

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Second, multiple regression was run to incorporate more of the variables. In this analysis, the dependent variable of average grade was regressed against many independent variables. The results of the regression are shown below.

```
Covariance Type:            nonrobust
================================================================================
                     coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------
const              82.7862      0.825    100.329      0.000      81.169      84.404
AMA                 1.7979      0.215      8.355      0.000       1.376       2.220
AMP                 0.0455      0.218      0.209      0.834      -0.381       0.472
2016               -0.0803      0.324     -0.248      0.805      -0.716       0.556
2017                0.0186      0.321      0.058      0.954      -0.611       0.648
2018               -0.9054      0.321     -2.817      0.005      -1.536      -0.275
2019               -1.4983      0.317     -4.732      0.000      -2.119      -0.878
2020               -1.6309      0.534     -3.055      0.002      -2.678      -0.584
2021               -1.0599      0.677     -1.565      0.118      -2.388       0.268
Technical          -0.7292      0.272     -2.679      0.007      -1.263      -0.196
High School         2.5317      0.784      3.227      0.001       0.994       4.069
Community School    0.7745      0.306      2.529      0.011       0.174       1.375
College             0.6110      0.316      1.936      0.053      -0.008       1.230
Central            -3.3530      0.866     -3.874      0.000      -5.050      -1.656
Eastern            -2.5650      0.844     -3.039      0.002      -4.220      -0.910
Great Lakes        -2.6164      0.837     -3.124      0.002      -4.258      -0.975
NM                 -1.0397      0.871     -1.194      0.233      -2.747       0.667
South              -2.5016      0.845     -2.962      0.003      -4.158      -0.846
Southwest          -1.9728      0.838     -2.354      0.019      -3.616      -0.330
Western Pacific    -1.0324      0.855     -1.207      0.227      -2.709       0.644
Pandemic           -0.9677      0.553     -1.750      0.080      -2.052       0.116
==============================================================================
Omnibus:                     2912.537   Durbin-Watson:                   2.044
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            80593.594
Skew:                          -1.925   Prob(JB):                         0.00
Kurtosis:                      21.167   Cond. No.                         35.0
==============================================================================
```

Figure 18: OLS Regression results with multiple variables.

From these results, the researchers could see some of the variables that were suspected in the descriptive statistics were statistically significant on the average grade. Of these, it became clear that the AMA grades are higher than the other two tests. However, grades in 2018 and after began to drop for many subgroups. Additionally, the R2 value was low indicating that this model would not be a good predictor of future grades. Further analysis in Python was conducted.

The third model run was a ridge analysis. Through the program, the most efficient alpha chosen was .01. When ridge regression was run, the following results were found.

intercept	79.9502777
AMA	1.174618292
AMP	-0.56536523
AMG	-0.61029575
2015	0.709779943
2016	0.638038828
2017	0.730961656
2018	-0.1842807
2019	-0.77483051
2020	-0.91588818
2021	-0.34940563
University	0.691308456
Technical	-0.13697036
High School	3.072760649
Community School	1.366447343
College	1.177209753
Alaska	2.02849526
Central	-1.20641489
Eastern	-0.42727439
Great Lakes	-0.52739204
NM	1.080782799
South	-0.35362437
Southwest	0.148173658
Western Pacific	1.110719228
Pandemic	-0.95171745
msq_test: 6.6212625202767805	
msq_pred: 6.879530726833391	
r2_test: 0.060536519587132465	
r2_pred: 0.04115014599453359	

Figure 19: Ridge regression results.

From the figure above, a few conclusions can be drawn. The AMA test has higher average scores than the AMG and AMP. Grades start dropping in 2018 and continued during the pandemic. Universities appear to have a higher average grade than any of the other school types. Western Pacific and Northwest Mountain have higher averages than the other regions, where Alaska has a much higher average than any region. Last, the pandemic did have a negative effect on grades, as those taken during the pandemic are lower than those taken before. This analysis continues to have a low R2 value and would not be good for using in predictions of future grades. However, the variables indicated do appear to influence the grades. Addressing these could help the researchers understand what is happening with the test grades.

Last, a fourth regression model was run to calculate the effect of the independent variables. The fourth regression model was lasso and resulted in the below table of calculations. The ideal alpha for this model was .002.

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intercept	80.32107
AMA	1.457975
2015	0.325977
2016	0.248683
2017	0.349425
2019	-0.46995
2020	-0.5291
Technical	-1.03133
High School	0.703316
Community School	0.039991
Alaska	0.625387
Central	-0.44377
NM	0.916281
Western Pacific	1.087526
Pandemic	-1.05191
msq_test: 6.647619038890845	
msq_pred: 6.888261679249922	
r2_test: 0.05304239946217559	
r2_pred: 0.0387148098902369	

Figure 20: Lasso regression results.

Limitations

The FAA Form 8080-08 tracks quarter by quarter assessment of all the 14 CFR Part 147 schools and measures their progress compared to the national norm based on the regulation outlined below:

> **§ 147.38a Quality of instruction.**
> Each certificated aviation maintenance technician school shall provide instruction of such quality that, of its graduates of a curriculum for each rating who apply for a mechanic certificate or additional rating within 60 days after they are graduated, the percentage of those passing the applicable FAA written tests on their first attempt during any period of 24 calendar months is at least the percentage figured as follows:
>
> (a) For a school graduating fewer than 51 students during that period - the national passing norm minus the number 20.
>
> (b) For a school graduating at least 51, but fewer than 201, students during that period - the national passing norm minus the number 15.
>
> (c) For a school graduating more than 200 students during that period - the national passing norm minus the number 10.
>
> As used in this section, "national passing norm" is the number representing the percentage of all graduates (of a curriculum for a particular rating) of all certificated aviation maintenance technician schools who apply for a mechanic certificate or additional rating within 60 days after they are graduated and pass the applicable FAA written tests on their first attempt during the period of 24 calendar months described in this section.
>
> [Amdt. 147-2, 35 FR 5534, Apr. 3, 1970, as amended by Amdt. 147-3, 41 FR 47230, Oct. 28, 1976]

The regulation presents its own set of problematic issues because of the duration of the tracking, the size of the cohort within a school and it only records the first attempt of an applicant. The second issue is found in the data sets itself as there is a "Two Year Accumulative" measurement that acts as a smoothing parameter and does not identify immediate and specific data issues or issues specific with a cohort.

Training, although having planned and executed for many years under the appropriate CFRs, does not serve individualized instruction. This is evident in classroom settings; thus, educators could find themselves teaching to the mean group and not assisting the outside edges of a normal distribution curve of learners. Various institutions were not well versed in multiple platform remote learning delivery systems and had not trained students and staff to acclimate to the use, quality and feedback needed to become successful users of such a product. The authors cannot presently account for any effect this could have had on overall grades. According to W.P, Marsh, an Airframe and Powerplant instructor at Hinds Community College in Mississippi, "federal law for licensing aircraft mechanics license was temporarily relaxed during the coronavirus situation." As each FSDO overseeing its cadre of schools may have authorized changes to the programs under their control, there is no central point to access and review each change authorized to each program and, therefore, cannot be considered in the current analysis, yet we find this an area of future investigation.

DISCUSSION

The below table shows the dated status of 14 CFR Part 147 appendices B, C, and D. These appendices express the regulatory authority for both what curriculum the AMTS must deliver, and the teaching level required for each subject area. Although neither investigated as part of this study nor part of this research, one could argue that if viewed in alignment with Figure 15, the AMG test grade drop appears to coincide with the 2017 revision date of the text. It is possible that this revision contributed to a drop in the grades. However, the drops in the AMG and AMP grades do not follow the same pattern possibly because these were last revised in 1992. One would expect similar changes to have occurred with all three exams to draw such a conclusion.

Table 3: Status of AMG, AMA, and AMP curriculum subject matter (11-06-2021).

General - Appendix B	As amended by Amdt. 147-5, 57 FR 28960, June 29, 1992
Airframe - Appendix C	Docket FAA-2017-0733, Amdt. 147-8, 82 FR 34399, July 25, 2017
Powerplant - Appendix D	As amended by Amdt. 147-5, 57 FR 28961, June 29, 1992

In general, industry practitioners believe that the grades lowered because the FAA changed the test. What would appear as the more correct statement is that the FAA changed the test questions, aligning with former Administrator's thinking (O'Brien, 1990) that teaching was aligning with the test questions. This would support the theory of teaching the test, the questions, and the corresponding answer to students at various institutions. Clearly, if the regulatory side did not change as demonstrated by both the AMG and AMP content since the 1990s, but the FAA was adding to the test question bank there appears a "lag" in the time for the questions to leak out to the public. As the FAA stated in 2017, only sample questions were provided to the public and new handbooks released as outlined below.

These handbooks were released in a more current revision status (date) showing that the regulations for the AMTS did not change (Table 4). Further investigation into how these changes effected the average grades could be conducted outside of this effort, which focused on pandemic effects.

Table 4: FAA's Airman Testing Standards Branch (AFS-630), publication dates for the AMT Handbooks.

AMG	AMG HB (FAA-H-8080-30A): October 2017
AMA	AMA HB (FAA-H-8083-31A): September 2018
AMP	AMP HB (FAA-H-8083-32A): September 2018

SUMMARY AND CONCLUSION

From the exploratory analysis preformed, the researchers could not account for the root cause for the drop in grades during the pandemic. Although very small, it is evident and requires further investigation at a more granular level. The other phenomena and more concerning are the grade drop in what is considered "normal times" or pre pandemic, additional investigation is needed. As a result of our investigation, the researchers can conclude that the KBT test results did decrease during the pandemic. With only this data, it cannot be determined which factor, if any, is responsible for the trend. It is correct to say that the results before the pandemic in the 5 years preceding it were already trending down. Additional findings show that certain institutions and regions have consistently higher test grades than others. Future research could investigate what caused the initial downward trend, what was being done at the institutions during the pandemic to mitigate a significant drop in grades, and which institutions were most successful during this time.

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