The COVID-19 Pandemic's Effect on Student Learning at Aviation Maintenance Technology Schools

BY

KATIE SHAKOUR[1], **ELIZA GALLAGHER**[2], **TIM RANSOM**[2], **KAREN JOHNSON**[3], **REBECCA SHORT**[1], **JONATHAN BECK**[4], AND **KAPIL CHALIL MADATHIL**[1,5]

[1]Center for Workforce Development, Clemson University, Clemson, South Carolina, USA,

[2]Department of Engineering and Science Education, College of Engineering Computing and Applied Sciences, Clemson University, Clemson, South Carolina, USA

[3]School of Aviation, Southern Illinois University, Carbondale, Illinois, USA

[4]National Center for Autonomous Technologies, Northland Community and Technical College, Thief River Falls, Minnesota, USA

[5]Departments of Civil and Industrial Engineering, Clemson University College of Engineering Computing and Applied Sciences, Clemson University, Clemson, South Carolina, USA

Author Note We have no known conflict of interest to disclose.

Correspondence concerning this article should be addressed to
Katie Shakour, Clemson University Center for Workforce Development
kshakou@clemson.edu
1 Research Drive
Office 402
Greenville, SC 20607

ABSTRACT

In March 2020, students across the country experienced disruptions to their learning due to the COVID-19 crisis. Aviation Maintenance Technology Schools (AMTS) were no exception. These schools relied heavily on hands-on learning to train the next generation of aircraft maintenance technicians, but, for varying periods, students were unable to attend in-person classes and complete hands-on projects. Schools could delay learning until they could resume in-person classes, or they could switch to remote lectures and complete required projects once they returned in-person.

Through a resilience engineering framework, this research explores AMTS' responses to the crisis and the effect both disruption and institutional response had on student learning. The research team conducted 43 semi-structured interviews with administrators, instructors, and students at AMTS nationally. During these interviews, participants shared their personal and their Part 147 schools' responses to the pandemic. Content analysis revealed that schools were under-prepared for any long-term disruption to their programs. Student learning suffered as a result. We discuss our research in relation to the effect on academic continuity and identify some ways which help mitigate disruptions.

Keywords: Aviation Maintenance Technology Schools; two-year college; COVID-19 learning adaptation; learning management system; resilience engineering; technology acceptance model

INTRODUCTION

Commercial and private air travel is critical to the United States economy (International Air Transport Association, 2018). The safety of that travel depends on a well-trained workforce of aviation maintenance technicians (AMT), and the Federal Aviation Administration (FAA) has oversight of all 183 Aviation Maintenance Technology Schools (AMTS). That oversight, granted and described in Part 147 of the Electronic Code of Federal Regulations, is so closely connected to the curriculum and certification requirements that AMTS are commonly referred to as "Part 147 programs."

According to the Boeing Pilot and Technician Outlook 2021-2040 Report, there will be a demand for 626,000 technicians in the coming years. Indeed, the aviation industry needs the number of new mechanics to increase 37 percent annually to bridge the gap between the retiring and hiring rates and to meet the projected demand (Aviation Technician Education Council [ATEC], 2018). These shortage estimates are exacerbated by findings that many individuals nearing retirement, including aviation maintenance workers, left the workforce early because of pandemic-related issues (Fry, 2020). Academic continuity for AMTS is crucial to meet current and upcoming demands in the field and thus to preserve the economic well-being of the country.

In March 2020, educational institutions across the United States experienced an abrupt halt to their in-person learning because of the novel COVID-19 virus spreading around the world. More than 25 million college students in the United States were affected, including all AMT students (Alexander, 2020). For AMTS, administrators and instructors had to consider how to continue to teach students while maintaining FAA accreditation standards. The FAA has strict requirements for student attendance, lab hours, classroom hours, order of instruction, total number of hours, and assessment methods (Barbagallo, 2015, pp.6-9). Many of those requirements had to be adjusted given the need to protect students, faculty, and staff from COVID-19, especially given numerous unknowns related to the virus in March 2020.

In response, the FAA provided six options for AMTS. One, AMTS administrators could build upon their existing, approved distance learning with some alterations, which included postponing examinations and testing. Two, administrators could create a temporary distance learning program. This option was included because the approval process for a permanent distance learning portion of the program would not meet the pandemic-induced immediate need for remote learning. Three, the FAA would permit a student to be absent up to 80 hours to account for the duration of COVID-19 infections. Four, AMTS could suspend their operations for a period. Five, a school could submit a proposal for an alternative response to COVID-19. Six, a school could request an exemption from a requirement.

Part 147 programs rely heavily on hands-on and kinesthetic learning to train students. Those established teaching techniques did not transfer directly or easily to remote learning, and the community was forced to evaluate how to teach students in changing circumstances that varied considerably from institution to institution. Each AMT program administrator applied for one of the options to their local flight standards office (FSDO) for approval (Black, 2020). However, schools were not guaranteed approval for curricular deviations. Each FSDO evaluated the proposed changes to curricula in their jurisdiction to determine if they complied with FAA regulations.

This research is part of a larger project exploring how AMTS responded to the COVID-19 crisis and maintained academic continuity. In this

paper specifically, we examine the pandemic's effect on AMT student learning.

THEORETICAL FRAMEWORK

We use the Resilience Engineering (RE) framework for this exploration of AMTS' responses to the COVID-19 crisis. RE is a "proactive approach that looks for ways to enhance the ability of organizations to explicitly monitor risks, and to make appropriate tradeoffs between required safely levels and production and economic pressures" (Madni & Jackson, 2009, p181). Resilient properties are linked to four basic abilities: respond, monitor, learn, and anticipate. The organization uses these abilities to adapt to disruptions. Within each disruption to the system, there are four phases to observe and evaluate: avoidance, absorption, recovery, and adaptation. Extending a preliminary study by Jain et al. (2021), we examine how resilience factors at AMTS affected student learning during the COVID-19 crisis.

METHODS

Building on the preliminary research by Jain et al. (2021), we developed interview protocols[1] that were then pilot-tested and refined to ensure communicative and theoretical validity (Tong, Sainsbury, & Craig 2007; Walther, Sochacka, & Kellam, 2013). Using these protocols, we conducted 43 semi-structured interviews with students, instructors, and administrators associated with AMTS in the United States. This interview approach allowed researchers to explore ideas and themes as they arose during interviews, rather than the inflexibility of structured interviews that do not allow any deviation from question sets. Throughout the larger study from which the results in this paper are drawn, we evaluated our research methods and analysis techniques using the COREQ checklist by Tong et al. (2007) to ensure quality.

While interviewing, we focused on the immediate learning responses AMTS took and probed about e-learning and digital learning tools such as virtual reality simulations and labs, technological resources designed to assist education, and ways administrators, instructors, and students maintained academic continuity. We were especially interested in how instructors and students continued required labs and practicals given the hands-on nature of Part 147 programs. These interviews provided a wealth of information about student learning in AMT programs during the pandemic, and those themes form the focus of this paper.

Participants and Sampling

In March 2020, Part 147 programs had two main options: switch to remote learning or temporarily halt instruction. Of our research participants' schools, about 11.6 percent closed until they could safely reopen for in-person learning. Students in those programs did not engage in any remote or distance learning. The remaining 88.4 percent of interview participants engaged in some sort of e-learning.

Once administrators made the choice to engage in online learning, they had various timelines for implementing online learning. Some instructors were allowed a month to move their courses online, while others had to use their evenings and weekends to create online courses in a shorter transition window.

To account for these stark differences in overall approach, we actively recruited individuals from programs that engaged with remote learning and from those that did not. Among those who engaged with remote learning, we made sure to include individuals from programs that implemented a temporary pause to make the transition online, as well as with those from programs that had an immediate transition. In some cases, we spoke with multiple individuals from the same program, which provided different perspectives and helped us triangulate relevant findings.

We identified study participants through established partnerships with the Center for Aviation and Automotive Technology Education Using Virtual E-Schools (CA2VES) at Clemson University, the NSF National Center for Autonomous Technologies (NCAT) at Northland Community and Technical College, and the Aviation Technician Education Council (ATEC). Participants were instructors, students, and administrators from AMTS from around the United States. We used email communication as our primary form of recruitment, and we advertised through the ATEC monthly newsletter. To expand the pool of participants, we also used snowball sampling, where a participant recommends other participants (Trotter, Schensul, & Kostick, 2015, p.675). We provided a $25 digital Amazon gift card incentive to each participant at the conclusion of the interview. The research team selected participants on the basis of two criteria: 1) if they were over the age of 18, and 2) they were a student, instructor, or administrator at an AMTS during March 2020 and for at least one subsequent semester. We stopped recruiting when we reached data saturation, meaning we gleaned no new information from subsequent interviews (Guest, 2015). This occurred within administrator, instructor, and student groups at different times during data collection because of the differing perspectives and experiences during the pandemic.

Data Collection

Three research team members conducted the interviews at a time convenient to the participant. The interviews ranged from 30-65 minutes and were conducted and recorded via Zoom with only researchers and participants present. Transcription was completed by the third-party secure service, GoTranscript, and transcripts were then verified against the audio recording to correct any transcription errors. After verification, transcripts were cleaned of all identifying information and participant names were replaced with a numerical code to protect anonymity. All quotations included in this paper use the numerical codes and we use they/their/theirs pronouns to further protect participants' anonymity.

Data Analysis

We created a code structure both inductively and deductively. In the familiarizing cycle of analysis, we used provisional codes from the

1 Please email authors for copy of the interview protocols.

preliminary study by Jain et al. (2021) to identify portions of the data that were strongly aligned with our theoretical frameworks. Multiple additional familiarizing passes used open coding in the Atlas.ti qualitative coding software to identify emerging themes and expand the existing code structure. These initial codes were reviewed and discussed to reach consensus among the research team, then sorted into categories as we transitioned to the sense-making cycles of analysis (Saldaña, 2016). Code-sorting resulted in five major categories: Perceptions of Administrative Structure, Perceptions of Learning Environment, Perceptions of Own Learning and Digital Self-Efficacy, Peer Interactions, and Broader Context.

One member of the team then made five separate passes through the entire set of interviews, extracting excerpts that fit within each category. Reorganizing the data in this way allowed us to identify salient themes within each of the overarching categories to make sense of the whole of the data (Saldaña, 2016). The findings in this paper include themes that fell in each of those five categories as they pertain particularly to student learning during each of the four RE phases.

RESULTS

These interview data provide helpful insight into how institutional and program resilience affected student learning in each of the four phases of the pandemic disruption.

Avoidance and Digital Learning Tools

Avoidance is the term used to describe aspects of a system or organization that help prevent a disruption from affecting normal operations. Avoidance includes the anticipation of disruptions and mechanisms in place before a disruption (Jackson 2010, p.12). In general, educational institutions across the United States were ill-prepared for a long-term disruption to in-person learning because they lacked avoidance mechanisms that maintained academic continuity. However, we found some exceptions and examples of avoidance mechanisms within AMTS. Participant 5, an administrator, had proactively addressed interest in distance learning from students who lived in remote places making a commute to the classroom difficult. To meet those needs, they had designed their program so that it could eventually become a distant-learning program for all the lecture portions. Half of their lecture courses were already approved for distance learning before the pandemic. “Really, as far as what we had to do, is secure final permission from the FAA for a number of courses…within a week we had the entire lecture.” Even before the COVID-19 crisis, they had “developed units that can be sent to the student to allow the students to do labs online.” For Participant 5, the change to a remote system was relatively seamless because of the prior incorporation of digital learning tools.

At the other end of the spectrum were schools that did not use any digital learning tools. One program administrator had to tell students

to actually check their emails, which they had never done before. Another program administrator, Participant 4, said "Everything was in-person lectures and in-person labs and projects" and the pandemic required a quick implementation of a learning management system (LMS) for all of their courses as they were not using one before March 2020. Where Part 147 programs with established digital footprints were able to avoid some of the immediate pandemic disruption, programs without this avoidance element bore the full brunt, making the next phase, absorption, more challenging.

Absorption and Struggles with Online Instruction

Absorption is the phase in which an organization continues to operate under disrupted circumstances, often with loss of functionality in key systems. In a resilient system, loss of functionality at one point can be absorbed by distributing the effects to other systems, allowing the system to continue functioning until the disruption is past. In the context of the COVID-19 pandemic, the absorption phase relates to the immediate responses in spring 2020.

Some Part 147 programs were unable to absorb the effect and instead suspended operations. "We're not teaching it or we're teaching it in-person." This firm statement by Participant 15, an instructor, captures the sentiment from Part 147 programs that chose to pause instruction rather than transition online. Such decisions were generally driven by concerns about maintaining the same standard online as in-person and about the amount of work it would take to move classes online. Instructors and administrators at these programs chose instead to work with health and safety officers to create COVID-19 safety protocols under which in-person instruction could resume. In some cases, the return was delayed as long as 6 months, creating a large break in academic continuity and student learning.

Even with online options, AMT students experienced interconnected issues with academic continuity. First, students experienced an abrupt change in learning and teaching. Before the pandemic, students were accustomed to going into school, listening to a lecture, and completing lab projects. They could get updates about their classes and schedule from daily in-person conversations. When the pandemic affected Part 147 programs, some students struggled because their program lacked avoidance mechanisms, and they had to learn new hardware and software. Participant 17, a student at a Part 147 school, said, "I'm barely getting used to it. I've never really been tech savvy to be honest. I can run a computer but going through the [LMS], uploading files, using Acrobat, all that stuff was new for me. It wasn't a pretty transition." Using digital learning tools and communication was new for many students, and some were reluctant to engage with these resources.

During the absorption period, instructors had a very short time to transition their classes to an online format, limiting their ability to create a robust online curriculum. As Kelly and Columbus (2020) noted, uploading lectures and accompanying slides is not the same as an in-person class. Students commented on the lack of engaging material when their classes moved to distance learning, with one participant describing "Death by PowerPoint" in contrast to the engaged in-person lectures. During remote learning, students listened and watched a lecture. However, they no longer had the projects that followed or hands-on demonstrations. Rather, they were assigned extra reading and writing assignments. Many instructors sent the students links of videos to watch on platforms like YouTube. Some instructors were able to livestream or record themselves conducting the labs, so the students could watch them immediately after the lecture. During the absorption phase, students relied heavily on digital learning tools and communication, with extra material that lacked the engagement they relied on in pre-pandemic times. This approach helped maintain academic continuity and avoid pandemic-caused disruptions, but the learning was not equivalent to pre-pandemic, in-person education.

In contrast, when administrators and instructors had previously incorporated e-learning and digital learning tools into their program, students did not express as much frustration with their pandemic-caused remote learning. Rather, students commented on technology being outdated or in need of an upgrade. "The software that we use for the drawings and the software we used for the basic electricity and the electric circuits is extremely outdated," said Participant 41, an AMT student. They wanted better and more resources, and when they elaborated they said, "actually, it's like a real good way of learning basic electricity but the execution. It was slow and unresponsive. All the modules that you would do were really, really, really long." Participant 37, a student at a different AMTS, wanted more 3-D models with cutaways and more virtual reality simulations because they "can see the internal components of things that we're discussing, [the instructor] could highlight what was going on, like, 'hey, when the piston is up in the compression stroke this is what's happening over on this side, exhaust gases are coming.'" They appreciated the immediate reinforcement of lecture material some of these digital learning tools provided. These students extensively using digital learning tools before March 2020 were not hesitant to engage in online learning, demonstrating its usefulness for avoiding effects from the pandemic. This is especially true when compared to their peers at schools that used digital tools minimally, such as using an LMS solely as a file repository, before the pandemic.

Recovery and Struggles with In-Person Learning

The recovery phase of RE includes the steps an organization takes to return to pre-disruption functioning (Jackson, 2010). After the initial disruption in spring 2020, schools entered the recovery phase during summer and fall, where they saw what worked and what did not for students. Whether programs paused instruction or transitioned to remote instruction, AMTS' return to any level of in-person instruction had their own struggles. Students had to maintain distance to comply with health and safety protocols, which was not always easy in a Part 147 program. Participant 37, a student, said they attempted to ask a nearby student a question, but their instructor reprimanded them to maintain distance. Participant 37 notes, "I'm like 12 feet away...It was almost like they didn't want us even talking to other students...it felt like we're always being watched." They de-

scribed how it was a completely different learning environment when they returned to the classroom, and the sense of community was different because of lost or reduced informal interactions.

Regardless of whether schools engaged with online learning, students also commented on the rushed schedule to complete all the hands-on projects when in-person classes resumed. Many schools created a compressed project-only schedule or conducted class when students would normally be on a break to get the students to complete the classes they began in January 2020. "It was very accelerated, so I wasn't able to take my time and understand the theories about it. It was more challenging…Everything was just rushed," said Participant 14 when speaking about the return to in-person learning. Because of the major disruption in academic continuity, students like Participant 14 struggled to keep up with the schedules their program instructors and administrators created.

Adaptation and Lasting Change

Adaptation refers to the long-term changes an organization makes to prevent further disruptive events in the future. In this phase, organizations change in response to what they learned. Adaptations within an organization are often determined by managers, so the administrator interviews are especially revealing for this phase. Administrators were generally hesitant to incorporate new technology into their programs moving forward, citing three main reasons. First, they were not confident the investment was worth their time. They perceived the digital learning tools as too expensive for their programs. Second, administrators argued that they had been teaching in-person for decades, and they did not see reasons to change even with the pandemic's effect on learning. Finally, instructors and administrators said that the AMT profession is hands-on and the teaching should be as well.

Contrary to the hesitations we heard about in our interviews, some AMT community members are eager to incorporate technology into their classrooms. Several articles in the ATEC Journal discuss ways to incorporate new technology and digital learning resources into schools. Steigerwald and Steigerwald (2018) discussed ways to use online systems to evaluate student understanding of the material. They found that overall student learning improved because online formats allowed for self-testing. Manson (2018) advocated using newer technology like virtual reality training for beginners. Morris (2018) advocates for using software like AutoCad to teach students drawing. Kim and Sterkenburg (2017) looked at implementing 3-D modeling and reverse engineering into their curriculum. Filgo (2017) advocated for incorporating simulations into the AMT classroom, and he provided a list of resources for interested individuals. Despite these calls for increased technology use in AMTS, Russo (2018) found that instructors were hesitant to integrate changes into their teaching. Filgo (2017) called aviation maintenance instructors "stubborn people, hesitant to change because they trust what works." In a later journal, Smith (2019) asks if AMT programs are training students for the test or the industry, and he joined Dyen (2017) in expressing a need for revisions to the curriculum. The pandemic might have provided the catalyst to respond to these calls, as revisions are currently underway with one of the COVID-19 relief bills. These digital learning resources would provide students tools to engage them if they were learning in-person or attending school remotely.

Overall Effects on Student Learning

The most significant effect on student learning was the delay between lectures and the hands-on projects. Students experienced delays whether their Part 147 school participated in remote learning or not. Some AMTS experienced as much as a 6-month delay between a lecture and the lab that accompanied it. Other schools were able to bring the students back after only a 1-month delay. No matter the length of the delay, instructors reviewed the relevant material with the students. However, students said that they still struggled with retaining the material. Participant 14 discussed how the delay affected their learning.

> I don't think it was that great because the PowerPoint right there in class, and then immediately doing the lab afterwards, you understand it more. When you separate those, you lose knowledge about it, I guess, over time, and then you forget how to do things.

Before the COVID-19 crisis, AMT students reinforced their learning with hands-on activities, rather than extra reading or writing on the concepts. With remote learning, they were expected to learn new material without reinforcement of previous material. Students were less confident of their learning in the online environment because of lack of active reinforcement through projects. As students struggled to learn, there was some hesitancy about how prepared they would be when they graduated. Participant 28 was especially concerned with learning basic electricity via e-learning. "Remote learning hurt me really bad because now I'm struggling when they bring up electricity questions or I have to troubleshoot something electrical. It's just hard for me to even know where to start." The student was told that they would make up the lost knowledge in the next class for electricity, but they felt that this was an insufficient answer because their foundational knowledge would always be weak. After an interview with one participant who was both an AMT instructor and administrator, we received a follow-up email that they had asked their students how they felt about their online learning. The students resoundingly responded that they were not confident in what they learned online, despite their instructor reviewing the material and expressing confidence in their knowledge

The largest challenge with switching to remote learning was that AMTS were unprepared for the mass disruption to learning that COVID-19 caused. In March 2020, many AMTS rushed to create online programs for their students. However, students struggled with the delays between lectures and projects and new learning styles. Robust online courses can be as effective as in-person, especially for lecture portions of courses, but they must go beyond uploading a PowerPoint and recorded lecture to an LMS. Instructors need time and resources to create online courses, and the rush to adapt in

THE 2022 ATEC ANNUAL CONFERENCE

PRESENTED BY American Airlines LOCKHEED MARTIN

MARCH 20-23, 2022

Tarrant County College

TARRANT COUNTY COLLEGE
FORT WORTH, TX

REGISTER TO ATTEND
ATEC-AMT.ORG/REGISTER

LOOKING TO HIRE?
Reserve a space at our Employer Link!
atec-amt.org/employer-link

HAVE AN EXHIBIT?
Showcase products & services.
atec-amt.org/exhibit

SPONSORED BY

AAR Doing It Right · AeroTrain · AM · AIRBUS · ASA Training Starts Here · Aviation Workforce Solutions · AVOTEK · CERTTEC · JSfirm.com · PIA · PIEDMONT · Republic Airways · Snap-on · UNITED

ATEC-AMT.ORG ATEC@ATEC-AMT.ORG 703.548.2030

spring 2020 provided no such opportunity. As a result, student learning was negatively affected.

AMTs are in high demand (ATEC, 2018; Boeing, 2021), and the COVID-19 crisis created issues with academic continuity for the next new hires in the profession. The transition to an online program was harder for students whose programs did not engage with an LMS or digital learning tools. They were more hesitant to turn assignments in remotely. This could have been mitigated if the schools had used an LMS and other digital learning tools, the students and instructors would not have had such an abrupt change in learning when the time came to learn remotely. Students that were familiar with e-learning before the pandemic had an easier transition when the pandemic abruptly halted in-person learning.

ACKNOWLEDGEMENTS

We would like to thank the National Science Foundation. This material is based upon work supported by the National Science Foundation under Grant # 2037809. We would also like to thank the external evaluators for the research suggestions. Our research is supported by Clemson University's College of Engineering, Computing, and Applied Sciences and the Center for Workforce Development. Finally, we want to thank the Aviation Maintenance Technology community especially the Aviation Technology Education Council, and the students, instructors, and administrators who participated in our research.

REFERENCES

Aviation Technician Education Council (ATEC). (2018). Pipeline Report December 2018. https://www.atec-amt.org/uploads/1/0/7/5/10756256/atec-pipelinereport-20181217_1.pdf

Alexander, B. (2020, April 30). COVID-19: Higher education resource center higher education town halls entangled insights. Entangled Solutions. https://www.entangled.solutions/coronavirus-he/

Barbagallo, J. (2015, June 5). Advisory circular FAA. https://www.faa.gov/documentlibrary/media/advisory_circular/ac_147-3b.pdf

Black, J. (2020, March 3). FAA Aviation Safety Memorandum Special Guidance for part 147 AMTS Regarding Training Interruptions Related to Coronavirus (COVID-19) and Applicable Deviations to Order 8900.1. FAA. https://fsims.faa.gov/wdocs/afs-1%20memorandums/covid-19/special%20guidance%20for%20part%20147%20amts%20regarding%20training%20interruptions.pdf

Boeing. (2021). Pilot and Technician Outlook 2021-2040. Boeing. https://www.boeing.com/resources/boeingdotcom/market/assets/downloads/BMO_2021_Report_PTO_R4_091321AQ-A.PDF

Dyen, F. D. (2017). A delphi study of aviation maintenance experts' recommendations for a model school curriculum. Old Dominion University Digital Commons. Retrieved from https://digitalcom- mons.odu.edu/cgi/viewcontent.cgi?article=1007&context=teach- inglearning_etds

Filgo, K. (2017). DIY Simulations: The Case for Using them and where to find them. ATEC Journal, 32(2), 5-10.

Fry, R. (2020). The pace of Boomer retirements has accelerated in the past year. Pew Research Center. https://www.pewresearch.org/fact-tank/2020/11/09/the-pace-of-boomer-retirements-has-accelerated-in-the-past-year/.

Guest, G. (2015). Sampling and Selecting Participants in Field Research. In H.R. Bernard & C.C Gravlee (Eds.), Handbook of Methods in Cultural Anthropology, (pp. 215-249). New York, USA: Rowman & Littlefield.

International Air Transport Association. (2018). The Importance of Air Transport to the United States. [online]. Retrieved from https://www.iata.org/en/iata-repository/publications/economic-reports/the-united-states--value-of-aviation/

Jackson, S. (2010). Architecting Resilient Systems: Accident Avoidance and Survival and Recovery from Disruptions. Germany: Wiley.

Jain, M., Morris, T., Beck, J., Johnson, K., Short, R., Shakour, K., & Chalil Madathil, K. (2021). Educational challenges presented by COVID-19 at technical colleges offering aviation maintenance technology programs. Computers in Education Journal, 12(1).

Kelly, A. P., & Columbus, R. (2020). College in the Time of Coronavirus. American Enterprise Institute.

Kim, G. and Sterkenburg, R. (2017). Introducing Reverse Engineering Technologies in an Aeronautical Engineering Technology Curriculum. ATEC Journal, 32(2), 12-18.

Madni, A. M., & Jackson, S. (2009). Towards a conceptual framework for resilience engineering. IEEE Systems Journal, 3(2), 181-191. doi:10.1109/JSYST.2009.2017397

Manson, D. (2018) A Possible Use of Virtual Reality Game Design for Aviation Non-Technical Training. ATEC Journal. 40 (1),21-30.

Morris, D. (2018a). Modernizing An Aircraft Drawing Curriculum Within the Boundaries of 14 CFR 147. ATEC Journal, 40(1),4-13.

Russo, W. (2018). Classroom Demonstrations: Education or Entertainment? ATEC Journal,40(2),11-15.

Saldaña, J. (2016). The coding manual for qualitative researchers. India: Sage.

Smith, C. (2019). Are We Training for Testing or Training for Industry?. ATEC Journal, 41(1), 27-31.

Steigerwald, J.E. and Steigerwald, A.L. (2018). Try, Try, Again: Do Multiple Quiz Attempts Really Benefit the Student?. ATEC Journal,40(1),15-19.

Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care, 19(6), 349-357.

Trotter, R., Schensul, J., & Kostick, K. (2015). Theories and methods in applied anthropology. In H.R. Bernard & C.C Gravlee (Eds.), Handbook of Methods in Cultural Anthropology, (pp. 661-694). New York, USA: Rowman & Littlefield.

Walther, J., Sochacka, N. W., & Kellam, N. N. (2013). Quality in interpretive engineering education research: Reflections on an example study. Journal of Engineering Education, 102(4), 626-659.