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FROM THE EDITOR.

Let me begin by expressing my gratitude to David Stanley and Crystal Maguire for offering me this exciting new opportunity with the Journal. It has been a pleasure to work alongside them over the past year and I will do my best to continue providing this valuable resource to the ATEC community.

New this year, authors of published articles in the Journal that draw particular interest from the ATEC community may be asked to present their work in the ATEC Webinar series. Those webinars with high attendance and positive reviews may then be approached to present at the annual conference. It is our intent that this process will allow us to provide more responsive and relevant material to benefit you.

As the Editor of this journal, it is my goal to work closely with both AMT faculty and industry members to increase the quantity and diversity of published articles by constantly reaching out to the aviation maintenance community in search of those who are writing about new ideas and even those who simply wish to read about new ideas. In doing so, I hope to foster a closer research community among us all, allowing the Journal to develop into an even more useful tool for collaboration.

Academic pieces in this issue:

- Don Morris from Southern Illinois University introduces us to the use of CAD software when teaching Aircraft Drawings as an FAR 147 subject area.
- Dr. John Steigerwald and Amy Steigerwald from Middle Georgia State University discuss the benefits of providing multiple quiz attempts in the classroom.

New to the Journal:
ATEC is now inviting opinion pieces from industry members that speak directly to AMT educators in an attempt to spark further academic research. In this issue:

- Denis Manson from Aviation Australia argues for the use of virtual reality in aviation human factors training.

Please join me in thanking the Editorial Board for their work in reviewing these articles. Their contributions are a vital part of what makes this Journal a success. It is my sincere hope that you enjoy this issue and I extend a welcome to anyone who wishes to provide feedback.

Karen Johnson
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ATEC COMMITTEE UPDATES

JAMES HALL
WSU Tech Aviation Technologies Dean & Annual Conference Committee Chair

ANNUAL CONFERENCE COMMITTEE

As a quick recap of the 2018 conference, according to the feedback survey, 87.7% of respondents were very satisfied with the conference. We added some great new break-out sessions this year that were very well received, while the feedback varied from session to session, most were rated very valuable. We surpassed our strategic plan goal of increasing attendance by 20% percent with a total of 191 registered attendees this year. Thank you to Amy Kienast for all your hard work to make the 2018 conference a success.

With Amy's Departure from the ATEC Board, Jim Hall from WSU Tech will be leading the conference committee for 2019. Building on the success of the 2018 conference, we are very excited about the 2019 ATEC annual conference which will be held March 17-20th in the Air Capital of the World, Wichita, Kansas where we intend to implement multitrack break-out sessions. Our proposed tracks are designed to closely align with the different roles of our attendees. The proposed tracks include: Instructor, Administrator, and Human Resources & Recruiting. We welcome the membership's feedback and hope to make the 2019 annual conference a jam packed experience at a new and exciting location.

JARED BRITT
Southern Utah University Director of Maintenance & Legislative Committee Chair

LEGISLATIVE COMMITTEE

The first part of 2018 brought with it an abundance of legislative activity for aviation maintenance education stakeholders. In conjunction with its Annual Conference, ATEC hosted its first Day on the Hill, facilitating nearly 30 meetings with congressional representatives.

A primary focus for that event was soliciting support for legislation that would incentivize industry-education partnerships through federal grants. The Senate bill aims to pursue solutions to imminent workforce challenges at the local level. Through ATEC, the education community voiced its support, and a house companion bill was subsequently introduced.

Also in May, after months of behind-the-scenes activity, a bipartisan group of Senators introduced S.2792, which would require FAA promulgation of a new part 147 within six months of enactment. The legislative step was taken after a decade of regulatory advocacy, and the realization that the agency is still years away from issuing a final rule. The ATEC-driven legislation was supported by twenty of our industry partners, a testament to the gravity of our current situation.

Over the summer, the committee will continue grassroots advocacy in support of these two important pieces of legislation and begin planning for the ATEC Fly-in, taking place Sept. 12-14 in Washington DC. Registration is open, I encourage all interested in furthering aviation maintenance technician education to attend.

MODERNIZING AN AIRCRAFT DRAWING CURRICULUM WITHIN THE BOUNDARIES OF 14 CFR 147

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ABOUT THE AUTHOR

Don Morris has an MS in Aviation Education from Embry Riddle Aeronautical University and a BS in Physics from Illinois State University. He is currently Assistant Professor in the Aviation Technologies program at Southern Illinois University, Carbondale (SIUC). Don learned drafting the classic way in high school before learning computer-aided drafting (CAD). He taught CAD at the middle school level before earning his aviation credentials, which include A&P with IA. For the past 15 years, he has owned and operated a small internet based hobby business selling his own technical drawings.

ABSTRACT

The nature of aircraft technical drawings has changed forever as part of the digital revolution. Drafting boards, T-squares, and blue print machines are all things of the past. Many technical educators feel that there is no longer any reason to teach traditional drawing techniques. However, mechanics still need to learn to draw by hand in order to create simple sketches and to properly lay out aircraft repairs. A Part 147 school is often caught between the need for fundamental instruction and the desire to modernize in accordance with industry standards.

This paper details three academic years of experience with incorporating Autodesk Inventor into the FAA subject of Aircraft Drawings. Selected portions of the curriculum were completed using free academic copies of Autodesk Inventor software installed in the department's existing computer labs. Six hours of laboratory time were used to teach the students a basic knowledge of the software and then to create installation drawings using pre-modeled parts. Student engagement and morale were boosted as the creation of physical artwork took second place to the arrangement of the views and details that were needed to communicate technical ideas.

This article provides a rationale for the use of CAD software in a Part 147 environment. It then shows how Autodesk Inventor was incorporated into our specific FAA approved curriculum. Observations and results from our experience are shared. Numerous other free or reduced cost software packages are also mentioned. Details of where to obtain various free and reduced cost CAD packages are given in appendix A. Appendix B shares other uses for CAD software in the Part 147 program at SIUC.

INTRODUCTION

Drawings are heavily used in aviation. The Chinese Proverb "a picture is worth 10,000 words" is often literally true (Larkin and Simon, 1987) – particularly when that drawing shows exacting details of how parts or systems interact. A skilled maintenance technician can glean tremendous amounts of data from properly prepared drawings. Whether they are simple sketches found on the back of a FAA form 337, the relative position of parts in an illustrated parts catalog (IPC), the details of how fuel burn rate varies with engine load and speed found on a Nomograph, or the detailed instructions found in an AD or STC, drawings may be used to communicate massive amounts of information in an extremely dense format.

In the not too distant past, drawings were painstakingly created using pencils and drafting tools. This processes is described by the FAA's own 1970 publication AC 65-9. However, the advent of computerized drawing programs changed this procedure. Beginning with "Sketchpad" programmed at Massachusetts Institute of Technologies in 1969, computer aided drafting (CAD) programs began to supplant hand created drawings. Autodesk launched its famous AutoCAD software in 1982. By the early 1990's, CAD technology was widely available on the personal computer (Brown, 2009). This availability led to widespread industry adoption. Today, few professionally prepared drawings are created by hand.

The author recently attended an industry advisory panel where a Dassault-Falcon technical recruiter strongly advocated modernizing the curriculum. He explained that the very nature of communication has become digital. What follows is his outline of a typical modern repair scenario in his facility. A Dassault-Falcon technician in the United States takes digital pictures of a problem, and emails the pictures to an engineer in France. The engineer pulls a 3D model off of the server, and uses it to review the structure of the aircraft before digitally modeling a 3D repair. This repair is sent to quality control in digital format, where it is or is not approved. If it is approved, the engineer uses his 3D software to generate whatever detailed electronic views of the repair are necessary to show the field technician how to accomplish it. These drawings and the digital model are emailed back to the United States. The model is fed into a Computerized Numerical Control (CNC) machine to produce the necessary parts and the drawing is used by the technician to install the parts. No paper copies are produced in the entire process. This scenario aligns well with the FAA 8083-30's statement that "it literally became possible to design a part and have it precisely manufactured without ever having it shown on paper" (FAA, 2008).

GENERAL EDUCATION IN A CAD ERA

No one familiar with industry disputes the fact that CAD has changed the way that technical drawings are created. "Once a tool that addressed a very specific professional need, CAD today is pervasive, touching just about everything that isn't created by nature" (Livingston, 2012). "CAD has changed the face of the design industry and has influenced the lives of designers and engineers worldwide" (Brown, 2009). The Dassault-Falcon recruiter's description of the modern system of design may be referred to as a "design-by-virtual model" paradigm, and it has replaced the older "design-by drawing" paradigm (Contero, Naya, Company, and Saori, 2006).

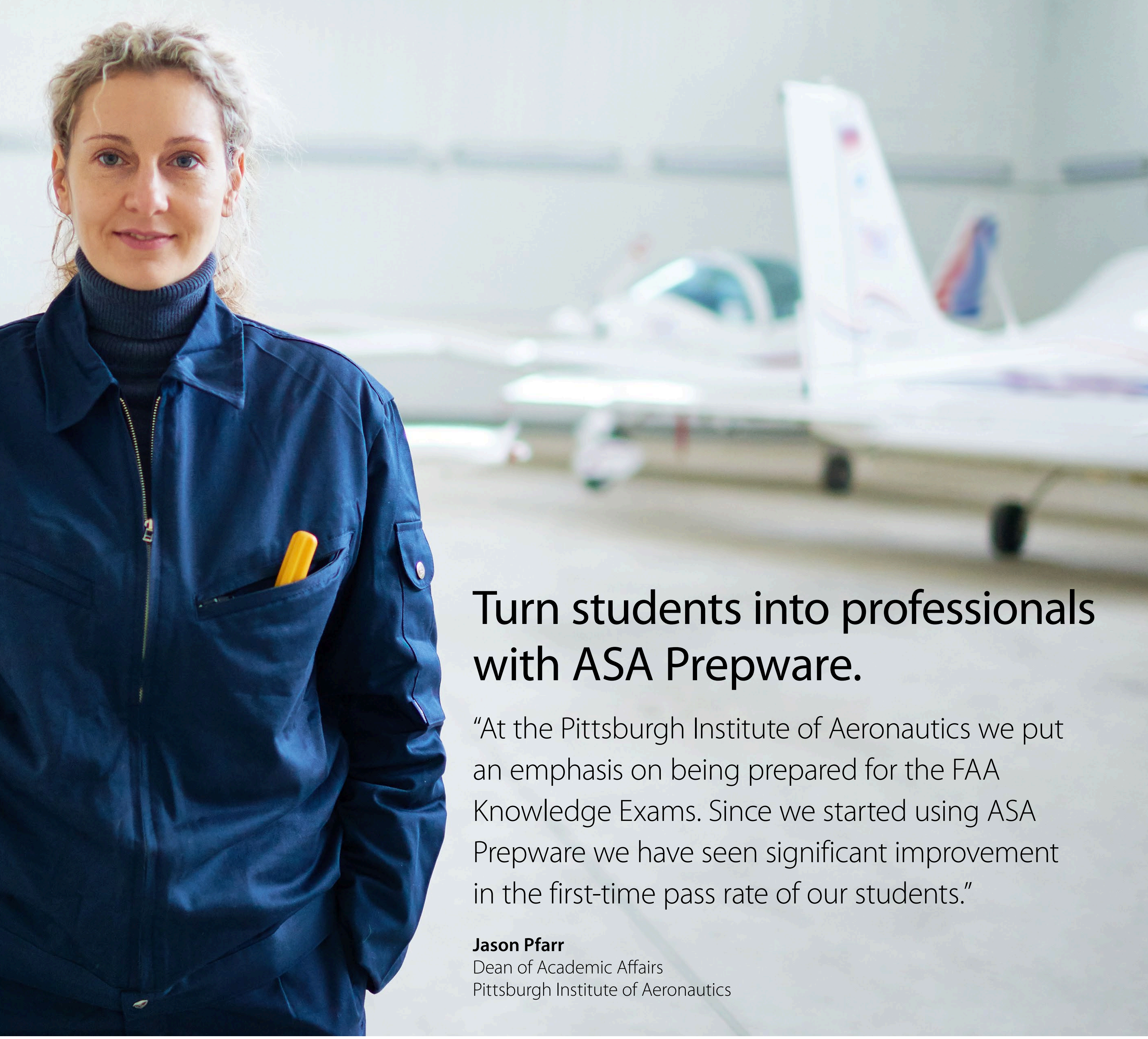
While it is clear that CAD has changed the way that drawings are created, there is no such consensus on the preferred way to educate individuals in an era where CAD is routinely used. Some assert that teaching drawing skills must be done in a computerized environment – and that the sooner this is accomplished, the better (Livingston, 2012). Assertions such as "technology educators cannot continue teaching without adjusting the curriculum to encompass new developments" (Becker, 1991) are used to spread the idea that responsible educators must ensure that their students are well versed in CAD, and consequently more employable.

On the other side of the divide, an altogether different set of educators feel that the use of CAD technology before a student has mastered the art of sketching by hand is detrimental to the student's conceptual learning. Varley and Company note that graphical literacy has suffered a decline in the age of CAD (2008). Alias, Grey, and Black assert that simple sketching and drawing are key in the development of spatial reasoning (2002). Brown asserts that the simple sketching and drawing that is supplanted by CAD-based systems were imperative in the development of true understanding (2009). Brown also notes that students learning CAD are eager to jump to the complex drawing functions that many software packages allow. She asserts that this short-circuits the development of spatial reasoning that is necessary for future success.

Susan McLaren eloquently discusses the technology divide behind traditional drafting skills and modern CAD skills in her 2008 work Exploring perceptions and attitudes towards teaching and learning manual technical drawing in a digital age. She notes that one group argues that manual skills are redundant and need no longer to be taught. The other group argues that manual skills are an important step in the understanding process. Regardless of this divide, industry's demand for CAD has changed the face of education (Becker, 1991). High school and even middle school students are being taught to use CAD software (Livingston, 2012). In the author's experience, many post-secondary students have already acquired a significant set of CAD-based drafting skills.

PART 147 SCHOOLS AND CAD

14 CFR 147 Appendix B defines the current minimum requirements for a drawing curriculum in a Federally



certificated aviation maintenance technician school. Such a school (referred to as a Part 147 school) must teach the students to:

1. Use aircraft drawings, symbols, and system schematics.
2. Draw sketches of repairs and alterations.
3. Use blueprint information.
4. Use graphs and charts.

These are minimums. Many Part 147 schools have additional requirements based on their operating certificates. There is no requirement that a student perform any drafting. There is also no requirement that a student learn anything about the modern CAD programs that have become industry standard. However, the fact that these programs have become standard in industry seems to imply that a student ready to enter industry would at least possess some knowledge of such a program.

While students are not required to develop drafting or CAD-based skills, students are required to understand and to interpret technical drawings. These drawings communicate information in a dense format that is based on spatial relationships. The ability to sketch or draw is seen as a key to forming developing spatial visualization skills (Alias et al., 2002; Ainsworth, Prain, and Tytler, 2011; Brown, 2009; Varley and Company, 2008; Contero et al., 2006). Experts differ as to whether the sketching and drawing should be performed on paper or on the computer, but it should be evident that practice manipulating details is critical if a student is to master the subtle nuances that exist in the language of drawings.

The very idea that drawing is its own form of language is helpful. Varley and Company note that all parties in a discussion need to share a common representation (2008). For aircraft drawings, this representation is the language of drawings, sketches, and diagrams. It is commonly used by higher order thinkers (Larkin and Simon, 1987). This language excels at depicting form and structure, showing processes, and comparing and contrasting details (Gastel, 2012). Some go as far as to say that it "should be explicitly recognized alongside writing, reading, and talking" (Ainsworth et al., 2011).

Each individual point (locus) of a diagram or drawing that is created stores information (Larkin and Simon, 1987). Just as rough drafts for essays are created and then corrected and tweaked, graphical depictions may be created and then revised (Gastel, 2012). This ensures that the details are correct, and that the person who interprets the drawing is able to accurately infer the details the drawing contains. This holds true regardless of whether the drawing in question was created through manual drafting or by a more advanced CAD program.

Certainly a great deal of industry change has occurred between the FAA's 1970 release of AC 65-9 and the FAA's 2008 release of AC 8083-30. Given the current state of the industry, it is desirable that students have at least some exposure to CAD. There are many high-powered CAD packages available (including Dassault's own Solidworks which is used across many industries and not just in aviation). These packages are intended to aid in the production of drawings. If properly taught, the features that make these packages helpful to industry can be helpful to student understanding as well. This is particularly true of some of the nuanced details which make this such a challenging area for many students. These CAD software packages are very expensive for industry, often costing several thousands of dollars per seat per year. Fortunately, many of them are available at low cost or free to approved educational institutions. Typically any Not-For-Proft school can be an approved institution. Table 1 shows several significant CAD packages, along with the educational pricing as of spring of 2017.

CAD INTEGRATION IN THE CURRICULUM AT SIUC

Southern Illinois University began incorporating CAD software into its Aviation Technologies curriculum in 2014. AutoDesk Inventor was the CAD package that was chosen for a variety of reasons: price, features, ready access to tutorials, and instructor familiarity. While the requirements of FAR 147 Appendix B are low, our approved Part 147 operating manual includes some fairly detailed drawing requirements. Over the past three years, students have performed basic computer modeling as part of a familiarization with the package. They have then used pre-modeled aircraft parts to produce installation and assembly drawings. Two lab periods of three hours each have been allocated to the use of the program. Additionally, live demonstrations of the program have been used during lecture times when covering many areas in our Drawings curriculum.

One area where Autodesk Inventor has been helpful has been in distinguishing between the three types of working drawings detailed by the FAA in both the AC 65-9 and AC 8083-30. Upon opening the program, users are prompted to choose between creating a part, an assembly, a drawing, or a presentation. These file types correspond well to the FAA's working drawings. The Autodesk Inventor part corresponds to an FAA detail drawing, containing all the details of a particular part. Once part files are created, they are then imported into assembly drawings (same nomenclature for both). Users cannot create assembly drawings without having parts to put in them. Once an assembly is created, the

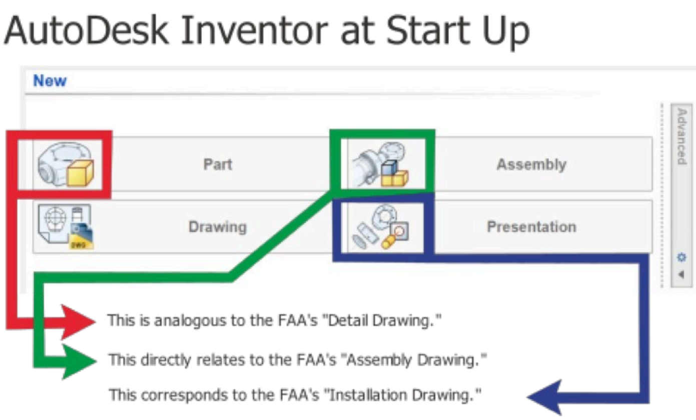


Figure 1: File Types in Inventor, and how they relate to the FAA's types of Working Drawings.

Some Significant Commercial CAD Packages		
Software	**Details**	**W/Discount**
Creo Parametric	From PTC. Was Pro/E. High end package for design, engineering, and simulation. Used extensively by high end industry. Base package $2200 per year.	Free 1 yr license, renewable
AutoCAD	From Autodesk. Longtime entry level industrial standard. Excellent cross industry data exchange. Focus more on drawing and less on design. From $1470 per year.	Free 3 yr license, renewable
AutoDesk Inventor	From Autodesk. Aimed more at design, engineering, and simulation. Has been aggressively upgraded through acquisition. From $1890 per year.	Free 3 yr license, renewable
SolidEdge	From Siemens. Industrial package, intended for product design, engineering, and simulation. From $75 to $329 per month.	Free for students
SolidWorks	From Dassault Systems. Industrial package, intended for product design, engineering, and simulation. From $1295 per year.	$150 per year

Table 1: Some CAD Packages. Price data from Web Search in 3/2017. Note that most educational discount versions have some disclaimers or limitations. All prohibit commercial use. Sources for software are in appendix A.

user can create an Inventor presentation which corresponds well to the FAA's installation drawing. In the Inventor presentation, parts can be exploded and rearranged to show how they fit together in the final product. Working with Inventor reinforces what each type of drawing is used for. Figure 1 shows the AutoDesk Inventor start-up menu and the types of files it creates.

One of the most important aspects of modern software packages such as Autodesk Inventor is that such packages separate the more complicated skill of digital modeling – which need not be taught to Part 147 students – from the

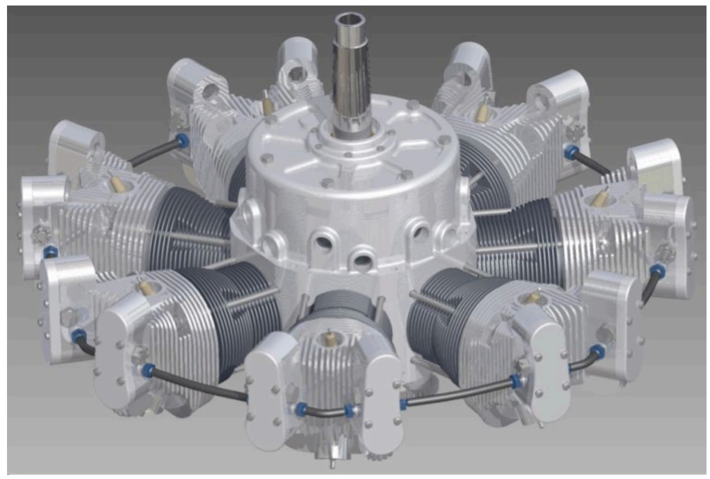


Figure 2: R160 engine assembly file designed and modeled by the author.

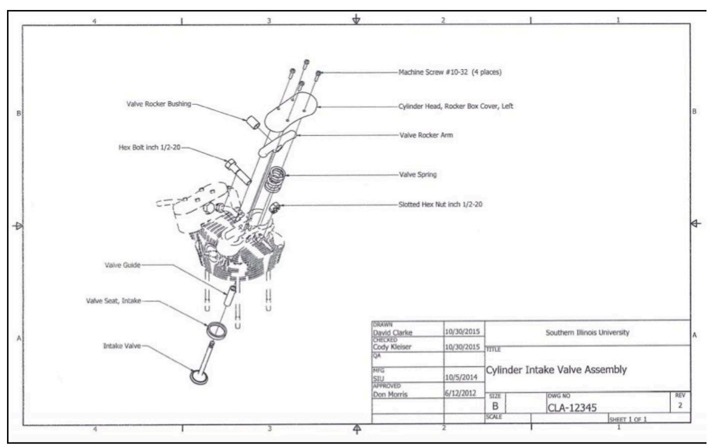


Figure 3: Exploded view of valve mechanism created by students. Used by Permission.

much more practical skill of creating a drawing. Students can therefore experiment with the presentation of information and spend less time struggling with the technical skill of drafting. This is advantageous to the student and to the instructor. When the student presents a drawing for critique, the drawing is still easily changed. The instructor can point out any deficiencies in the drawing, and the student can make minor revisions without literally going back to the drawing board. As students experiment with and manipulate the various drawing elements and line styles, they are also learning the language of drawings. This is a substantial help in the interpretation of drawings as well.

Figures 2 and 3 are provided to illustrate the difference between digital modelling and digital drawing. Figure 2 shows a very large and detailed assembly file created by the author. It shows a hypothetical R-160 engine. Figure 3 shows an exploded view of the valve system of that same engine. This drawing was created by inexperienced students from the digital model in under an hour. They were justifiably proud of their work (as was the author).

THE IMPORTANCE OF MANUAL DRAFTING AND DRAWING

This article should in no way be understood to insinuate that traditional paper and pencil drawing skills are obsolete. Drawing by hand is not only a valuable stage in the learning process (McLaren, 2008), but it is also an essential part of laying out repairs for aircraft. In many cases, needed repairs are directly drawn onto the skin of an aircraft – and this is not possible with any CAD system of today. Many of the tricks used by the paper and pencil draftsmen of 40 years ago can result in great time savings on the shop floor. Bisecting angles, laying out circles and hexagons, locating the centers of circles and arcs, and laying out even rows of points are all very important skills in a productive sheet metal technician's repertoire. The drawing portion of the General Curriculum allows these skills to be introduced and practiced long before a rivet gun is handled.

In addition to lay out skills, manual sketching of a less precise but still technical nature will continue to be used by Airframe and Powerplant mechanics for as long as pictures continue to convey information. The use of such sketches on form 337's continues to be relatively standard practice. The author's opinion is that students should be encouraged to use sketches wherever practical, including on tests and examinations. This encourages the student gain familiarity with the medium. It also has a way of revealing student knowledge or misconceptions in ways that are not possible with words alone.

EXPERIENCES INTEGRATING CAD INTO AIRCRAFT DRAWINGS AT SIUC

Initially, the reason that CAD was introduced into the curriculum was to create a limited degree of familiarity with electronic drawings. Most students responded enthusiastically to using Autodesk Inventor. After learning that they could download free Autodesk software, a number of students acquired the software for their own personal betterment. In the lab, student drawings created with CAD were of much higher quality than manually created drawings from previous classes.

One of the biggest advantages to the medium was the ability to revise drawings. Before using CAD, the instructor could not suggest minor changes to the student's work without requiring the students to make a completely new drawing. This was often not practical due to time constraints. On the computer, student drawings could be critiqued before changes were difficult to make. Asking the student questions about the drawing was a very useful technique. If the student had to resort to long verbal explanations, the author could point out that additional details needed to be included on the drawing for when the student was not present to explain. Often the selection of a different view, the repositioning of a part, or the use of pointed notes was all that was necessary to complete the drawing. Under the old paradigm, students concentrated on the "artwork" required. Under the new paradigm, students were free to concentrate on the way that the drawing could communicate the information.

This change was evolutionary, and not revolutionary. At the time of publication, no students who went through the modernized curriculum have graduated from the (4 year) program, so no long-term industry feedback exists. However, the short-term feedback from the students has been good. They have been positive about the training they had, and most would like to see further integration into the curriculum.

SOFTWARE SPECIFIC EXPERIENCE WITH AUTODESK INVENTOR

It is not the purpose of this paper to either promote or demote any particular software package. In the author's experience, most of these packages can do approximately the same things. The user interface, however, can be quite different. This tends to lead to brand loyalty among users. Once a designer becomes comfortable with a particular system, it is unlikely that they will wish to learn a new one (Piegl, 2005). This is probably a major factor in most significant software companies offering free or reduced cost versions. AutoDesk's stated goal is "to capture the hearts and minds of the next generation to get them proficient and passionate about using [AutoDesk] products" (Livingston, 2012). The author is happy to give AutoDesk the opportunity to reach students in exchange for free use of AutoDesk tools in the classroom.

Not all aspects of this experience have been positive. One of the most frustrating aspects of Autodesk Inventor is the lack of backwards compatibility. Each year, a new version of the software is released. Each new version can load drawings and models created in the previous years, but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once a drawing has been saved in a newer version of the software, it cannot again be loaded into an older version of the program. This has the effect of forcing all instances of the program to be updated every time any single instance of the program is. Although Autodesk probably has sound financial reasons for this aggressive marketing model, it is extremely frustrating in an academic world where computer labs are maintained by others, and sometimes different computer labs have different versions of the software.

On the subject of frustrations, there are a few more worth mentioning. Inventor does not have an autosave feature. This can lead to a great deal of trouble for students who are not used to saving as their work progresses. Another frustration is that the software can be used on Windows operating machines only. This also somewhat limits the student's ability to download and use copies of the software on their own time. Finally, the free educational version of the software does not come with any form of technical support. Because the program is quite complex to install and to operate, this could be a significant strike against Autodesk for many schools.

The lack of technical support for Autodesk Inventor is balanced by a large number of free tutorials available within the program, on various web sites, and on Youtube. The Autodesk Corporation itself records and allows free use of training webcasts. Many individuals also create their own tutorials for Autodesk products. There are a large number of books and training courses centered around Autodesk products. In the author's experience there are significantly more training resources available for Autodesk than there are for the other software brands. With a little time and dedication, it is quite possible for a person to train themselves to be highly skilled with Inventor. This allows Inventor to become a very valuable tool in the school itself. For additional details of this within SIUC's Part 147 environment, see appendix B.

CONCLUSION

Time constraints imposed on a typical Part 147 school do not allow time for mastery of extraneous skills such as CAD modelling. Nevertheless, the shift in industry away from paper-based drafting towards computer-based modeling and graphics is real. "To stop such technological phenomena from infiltrating our society is not a feasible goal" (Brown, 2012). In order to produce students with relevant employment skills, at least some degree of exposure to modern systems is wise.

In the limited amount of time a typical Part 147 school can spend on Aircraft Drawings, it is not practical to create and recreate many drawing from scratch. The ability to edit drawings leads to far more effective time use. This, in the opinion of the author, is where the computer excels. Students are given more opportunities to learn the language of drawing as the creation of physical artwork takes second place to the arrangement and rearrangement of details and views used to communicate technical concepts.

Between 2014 and 2017, SIUC students responded well to limited exposure to CAD based drawing systems as part of the Aircraft Drawing portion of the General curriculum. The expenditure for the school was negligible. All of the software used to date was free for academic use and the installation was done on existing computer systems. Student enthusiasm was high, and student produced drawings were of superior quality to those that were produced by hand before integrating CAD into the program. Additionally, a number of students have gone on to learn and use the available software on their own, adding significant skills to those they already had.

After three years, the author is actively seeking ways to increase the use of such technology within the boundaries of part 147. Since neither 14 CFR 147 Appendix B nor most Air Agency certificates indicate the manner in which the drawings will be used or produced, there is significant freedom to use CAD software in the program.

AREAS FOR FUTURE INTEGRATION AND EXPANSION

As 3D printing and CNC machining technology become cheaper and more widely available, the skills to use them will only become more integrated into the job descriptions of future mechanics. To this end, the author intends to expand the use of these systems in classes as much as possible. One simple plan for next year's class is to allow students to design and build their own 3D printed ID plates for their tool boxes as part of the familiarization process with CAD. One SIUC student has already done this using his own 3D printer, and the resulting plate garnered a lot of student interest – see figure 4. In the experience of the author, any process that combines learning and general student enthusiasm is worth pursuing.

Figure 4: 3D printed nameplate with black and silver paint. Included by permission.

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APPENDIX A

Web Addresses to Obtain Free or Reduced Cost Software

PTC. Creo Parametric*. Free Student Edition may be downloaded from http://www.ptc.com/academic-program/products/free-software. Free software features a 1 year license which is renewable. Other free engineering software titles such as MathCAD are available from this location as well.

AutoDesk. (AutoCad and Inventor)*. Free educational version of software may be downloaded from http://www.autodesk.com/education/free-software/featured. Free software includes a 3 year license which is renewable. Many other Autodesk graphics creation titles are also available at this location.

Siemens. SolidEdge. Free student software can be downloaded from https://www.plm.automation.siemens.com/en_us/academic/resources/solid-edge/student-download.cfm. College and University educators go to https://www.plm.automation.siemens.com/en_us/academic/resources/solid-edge/educators/index.shtml to discuss pricing and sourcing.

Dassault. SolidWorks**. Information can be obtained from https://www.solidworks.com/sw/education/student-edition.htm. Academic versions are available at various web stores that specialize in academic software, but there is no free version.

* The author has personal experience with the free versions of these software titles, and can verify that they are truly free for educational purposes at the time of writing this article.

** The author has personal experience with this software, and can verify that it is not free for educational purposes at the time of writing this article.

APPENDIX B

Additional Uses of Engineering and CAD Software in a Part 147 Environment

The need for custom-made tools, training aids, and equipment is as diverse as are Part 147 schools. The recent explosion in rapid manufacturing has made the self-design and fabrication of many of these much more practical. At Southern Illinois University, the Aviation Technologies Department has a small CNC machine. It has been used to construct training aides, tools, and even a few appropriate aircraft parts to be used “for training only.” An example of what has been produced with Autodesk Inventor and this machine is detailed in a previous issue of ATEC Journal in the article “Demonstrating Aerodynamic Controls in a Wind Tunnel” (Morris, 2016). 3D printed parts have also been used in student-constructed projects and in labs. For both machined or printed items, the parts need to be digitally modeled before they can be produced. Having ready access to powerful 3D modeling software makes this much easier.

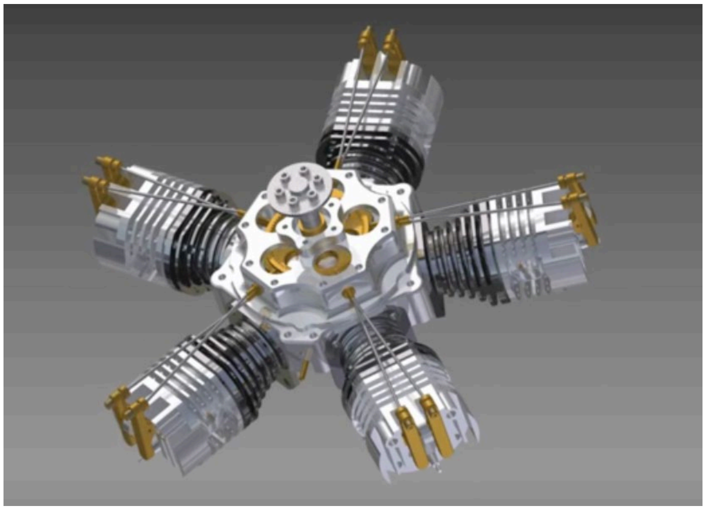

Figure B1: Frame from an animated radial engine created by the author.

Another use that the author has found for Autodesk Inventor is to create technical drawings for lecture presentations and lab projects. Before learning Inventor, the author had to rely on a much more primitive software package to create drawings. With Inventor, the fabrication instructions for sheet metal projects are much clearer and easier to understand. Delving deeper into the capabilities of the program, the author has been able to illustrate different concepts using animations rendered in Inventor. Figure B1 (Morris, 2014) shows such an animation that has been used in class and posted to Youtube. Non-technical drawings and illustrations are now well within the grasp of the operator, and the author has used non-technical graphics created in Inventor in PowerPoint presentations, in illustrative lab manuals. Additional graphics have been created for use in and anticipated future publication of a book on sheet metal techniques.

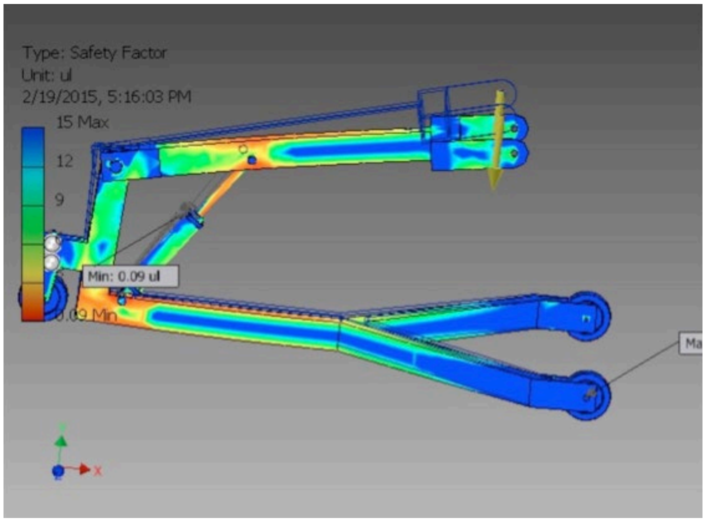

Figure B2: Automated engineering strength calculation of author designed ground servicing equipment.

Finally, the author has also found the ability to perform an detailed engineering analysis on a 3D model to be quite valuable. Figure B2 shows one aspect of such a report, done on a combination jack and dolly designed for titlted hangaring of a Gulfstream GIII.

Even programs without access to digital fabrication tools may be able to use CAD software to generate training aids and parts, as low cost machining and printing services are readily available. Most 3D printing services require the data to be submitted in STerioLithography (STL) format. 2D machining processes such as water jet and plasma cutting typically can use Drawing Exchange Format (DXF) files. 3D machining processes often utilize Initial Graphics Exchange Specification (IGES). Most CAD packages can export data in these and many additional formats.

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TRY, TRY, AGAIN: DO MULTIPLE QUIZ ATTEMPTS REALLY BENEFIT THE STUDENT?

By **John E. Steigerwald** and **Amy L. Steigerwald**

ABOUT THE AUTHORS

John Steigerwald is a tenured assistant professor at Middle Georgia State University. He is the former Director of Aviation Operations responsible for the school's 34,000 annual flight operations. Prior to holding that position he was the Dean of Aviation Science and Management at the institution. Before accepting an academic position, John was an FAA pilot examiner for the L-39 experimentally certified military aircraft. He holds an ATP and CFIIMEI flight instructor ratings. He has a Master's degree in Space Studies and a Doctorate in Management of Engineering and Technology. Amy Steigerwald is a graduate in Health Sciences from American Military University and serves as John's research assistant while pursuing a Medical Degree.

ABSTRACT

Traditional assessment of student performance takes the form of short, focused quizzes reviewing content recently presented. Additional assessment is often administered in one or two major exams covering content presented by the midterm or a final comprehensive exam, or some type of conglomeration of all three. The test taker usually has one opportunity to demonstrate subject matter knowledge on each assessment and little to no additional learning takes place throughout the assessment process. This study compared the final exam performance of two groups of students taking identical courses with one group having unlimited quiz attempts and the other group having just one opportunity. Final exam performance was significantly better with the first group suggesting that using the quizzes as a learning tool is more beneficial to the student than simply using quizzes as an assessment tool.

Keywords: assessment, unlimited attempts, quiz, exam, learning

The process of learning assessment is an integral component of education. In order to have confidence that knowledge transfer has occurred, there must be an assessment of that knowledge. The procedure can be accomplished in various forms including written quizzes and exams, oral questioning and presentation, or demonstration of skill such as in aviation or driver's license certification. In the education setting, the most practical and easiest to administer is the short quiz assigned after the lesson has been completed by the student. Often the quiz is a few questions, of a timed duration, for which the test taker has one opportunity to respond. Students have the ability to learn from this type of assessment if they are given some feedback related to their responses. When given one attempt on the original quiz, students do not have the ability to demonstrate learning from the quiz until the final exam is administered and the assessment for that content is completed.

Consider the effectiveness of this one and done approach. Such an assessment procedure does not appear in any area of learning except in academia. Real teaching seeks to train and educate an individual through an iterative process. We teach a little bit and, predictably, the student learns a little less than what we taught. We assess the progress and go back and teach again and then introduce new material. We assess again and find the student has learned a little more, and so it goes. Think back to the process an individual endures while learning to drive. Each lesson builds upon the previous, but the student driver does not proceed until they have demonstrated the ability to safely maneuver the vehicle. That ability is only obtained by a near constant act of teaching, assessing, feedback, and re-teaching as necessary. Why then do we academics stick to administering one, timed quiz and then move on to the next lesson most often without a review of any kind?

Students probably comprehend better than teachers that the assessment process they endure is also a learning process. They want to know what questions were answered incorrectly. How often do teachers hear a student ask, “What did I get wrong?” Would just knowing what questions were answered incorrectly result in the transfer of knowledge to the student being assessed? Some students will research and hunt for the correct response, others will exclaim, “Oh, I knew it!” Still other students will have wavered between answers during the quiz and later lament, “I shouldn’t have changed my answer!” During all this anguish, students are still learning, but unfortunately, the time to assess that learning in the near term has now passed. This is the problem: traditional learning assessment does not provide additional or improved learning. The purpose of this study is to investigate the effectiveness of an alternative assessment process.

Traditional quiz type assessments afford the student with one opportunity, usually timed of short duration, with minimal to no feedback. Students complete the quiz and then move on. When quizzes are administered online, it can be argued that students can work-around the system by sharing responses, copying course content, and employing other methods of satisfying the requirements to complete the quiz, while exercising little to no effort to actually learn the important concepts or content of the lesson. This situation is supported by previous research, which indicates students given unlimited attempts learn less (Yourstone, Kraye, & Albaum, 2010). However, with the technology advancements in learning management systems there are now numerous methods to craft quiz parameters that will minimize student work-arounds and enhance the integrity of the assessment (Ghazia, Ajani, David, & Wallini, 2016). Preventing copying of quizzes, prohibiting multiple open browsers, and maintaining large question banks to randomize quiz question content are a few examples.

More recent studies indicate that unlimited quiz attempts, also called self-testing, improved the performance on the exam scores, and interestingly, the improvement was related to the number of attempts, not relative to the score on those self-testing attemtps (Panus, Stewart, Hagemeier, Thigpen, & Brooks, 2014). Allowing students to retest on a major exam such as a midterm or final exam yields similar expected results. When the questions are the same, students predictably improve their score (Wilsone & Bailey, 2012). This approach, while beneficial to the student and promoting good reviews for the instructor, fails to convince that multiple attempts on quizzes prior to the exam would also yield similar results. In addition, simply retaking the same test may be more of an exercise in research and memory ability than actual learning. To carry that process to the extreme, why not simply make the test questions available to the student before the test is administered? In the end, that process itself is a learning experience for the student who takes the time to prepare, yet little research had been accomplished to determine the effectiveness of "teaching to the test" versus traditional content delivery methods. Using assessment as a teaching tool along with timely feedback goes beyond the practice of teaching the test. It creates an environment where the learner has time to reflect on the question and response, (Edwards, 2012), instead of simply selecting an answer and moving on. Providing students with unlimited quiz attempts affords them an opportunity to "self test", provided the process is structured to promote active learning and not mere memorization or choice elimination (Turner, 2015). The effectiveness of such an approach is testable as demonstrated in Panus et. al.

METHOD

Participants

This study captured quiz and exam grades from Aviation Law classes from the period 2017 – 2018, after the courses were completed and final grades were issued. No personal contact with the students in the courses was made or attempted while collecting the data and no personal information of the students was recorded. The age, race, gender, grade point average, degree or program, identification numbers, or other demographic or classifying information was not identified, collected, or recorded. The sample consisted of university level students enrolled in the courses and no effort was made to select or deselect individuals from the overall student population or from within the courses.

Assessments and Measures

The quiz attempts and test scores were collected from two courses of identical length taught by the same instructor, delivering the same content in the same manner. The course was an eight week course delivered online using the D2L Learning Management System. Five quizzes were administered, one each week from weeks one to four, and the fifth quiz in week six, each quiz being ten questions in length, randomly selected from a questions bank of 30 to 45 available questions, depending on the quiz. There was a fifteen minute time limit. Quizzes were opened at the beginning of the course and were always available. Group A (20 students) was allowed unlimited quiz attempt, Group B (28 students) was allowed one quiz attempt.

The grade of record was the score obtained from the last attempt. At the conclusion of the time allowed to complete the quiz, the quiz would close and the grade would be automatically submitted. Students could then view the questions that were on the quiz with all the possible answers, but no correct responses were given to questions answered incorrectly. Saving or copying the questions was not possible, however, it is acknowledged that students could use a digital camera or copy the questions manually in order to maintain a record of the question. A detailed examination of the scores related to each attempt was not conducted, however the average number of attempts per student was 3.03, suggesting that students did not prolifically engage in work-arounds to improve their score. A large question bank and making the last attempt the final grade probably limited student fishing expeditions to discover all the questions. A more detailed analysis would be required to clearly define that premise.

Results

The data was collected using Microsoft Excel 2014. This data is shown in figure 1. To determine the significance of the data, the means of the final exam test scores between the two groups were calculated and compared using the t-test (82.4, 72.07, $p = .0001$) and resulting in a t-value of 3.858 (figure 2). The result between groups was significant at $p < .05$. The means of the average quiz scores between the two groups were calculated and compared using the t-test (87.06, 79.75, $p = .0003$) resulting in a t-value of 3.854 (figure 3). The result between groups was significant at $p < .05$.

The means of the quiz and final exam scores were also compared within the groups. For group A, which was the group with unlimited attempts per quiz, the t-test was used (t-value 1.995) to compare the scores within the group (82.4, 87.06, $p = .0532$) (figure 4). The result within the group was not significant at $p < .05$. For group B, which was the group allowed one attempt per quiz, the t-test was used (t-value 3.448) to compare the scores within the group (72.07, 79.75, $p = .001$) (figure 5). The result within the group was significant at $p < .05$.

Discussion

There was a statistically significant difference between the final exam scores from Group A and the final exam scores from Group B. Students scored better on the final exam when given unlimited attempts on the assessment quizzes taken with each unit within the course, than students in Group b who had one attempt per quiz. This suggests that

students continue to learn during the assessment process. In Group A, the students had unlimited attempts, however, there is no indication that students attempted to work around the system and try to view all the available questions on each quiz as a means to prepare for the final exam. Students would see a duplicate question on a quiz 8.3% of the time. Therefore over the span of three quiz attempts (30 questions), the student could expect to see about three duplicate questions. The rate of question duplication would increase as the number of attempts increased until the entire question bank had been accessed. However, the average number of quiz attempts by students in the study was 3.03, therefore a significantly greater number of quiz attempts would need to be accomplished in order to amass a meaningful collection of quiz questions to prepare for the final exam. In further support of this assumption, the t-test score (t-value 1.99) was low when comparing means within Group A. There was not a significant statistical difference between the quiz score and the final exam scores in Group A.

There was a significant difference between the exam scores and quiz scores in Group B where students were limited to one quiz attempt (resulting in poorer exam scores). Students performed an average of 10% lower on the final exam than on the quizzes, indicating that fewer attempts result in less student learning on the assessments. This result supports the prior analysis between Group A and B that improved student learning occurs when more quiz attempts are completed.

Traditional thinking constructs assessments to be completed one time after the lesson content has been presented. Students have limited availability to obtain feedback, and to apply that feedback to additional assessment or learning. With the ability to create assessments using random question selection from large question banks, automatic grading, easy quiz creation and editing, adjustable timing and number of attempts, instructors have the ability to create customized assessments best suited to the population and course content. Instructors also have the ability to make online delivery more secure by locking browser manipulation, prohibiting page copying, and randomizing question inclusion.

While all these aspects of control are important, this study indicates that students do learn from being assessed. The successful transfer of knowledge is the ultimate objective of the course. If unlimited attempts on assessments contributes positively toward achieving that goal, then that is one more tool in the teacher's bag that can be successfully employed. Additional investigation is necessary to explore the nuances of this conclusion in order to improve this procedure. For example, this study has not investigated if unlimited quiz attempts are better than perhaps five attempts, or if those attempts would improve learning if attempted one per day or all on the same day. The results of this study indicate that there is significant improvement in final exam test scores when students have unlimited attempts on quizzes throughout the course compared to students with only one attempt per quiz.

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A WORD FROM THE INDUSTRY.

The ATEC Journal is pleased to present this new Opinion Editorial section from members of the aviation maintenance industry. These Op-Ed pieces provide an opportunity for industry to speak directly to academia in hopes of sparking research interests in areas that are important to the advancement of aviation maintenance education and training. The opinions expressed here are those of the author and are not meant to be an academic research paper, rather they are meant to start a dialogue between these two sides of the aviation maintenance field.

A POSSIBLE USE OF VIRTUAL REALITY GAME DESIGN FOR AVIATION NON-TECHNICAL TRAINING

By **Denis R. Manson**
Aviation Australia

ABOUT THE AUTHORS

Denis Manson is an Australian Licensed Aircraft Maintenance Engineer (LAME) with 36 years industry experience. Apart from his trade qualification, Denis holds a Bachelor of Business and Certificate IV in Workplace Training and Assessment.

He has worked as a licensed technician and training professional in airline and general aviation, including rotary wing search and rescue and emergency medical operations. Denis has a particular interest in instructional design and new technologies for training. He currently works at Aviation Australia in Brisbane, where he has assisted with designing and implementing courseware into their new training college in Saudi Arabia.

ABSTRACT

Well-constructed Human Factors (HF) training provides a more targeted appreciation of human interactions and fallibilities than comes from living the slow turn of real life, where we gather our own experiences and learn from our own mistakes. In the aviation business, we have the honor of learning from the mistakes of others.

While parts of the HF training community are striving hard for modernity, has the conduct of much HF and Crew Resource Management (CRM) training become too comfortable and complacent? Is it time to promote constructive worrying about how we are serving the industry?

- Older maintenance personnel are bored with the standard format and case studies for their HF refresher training.

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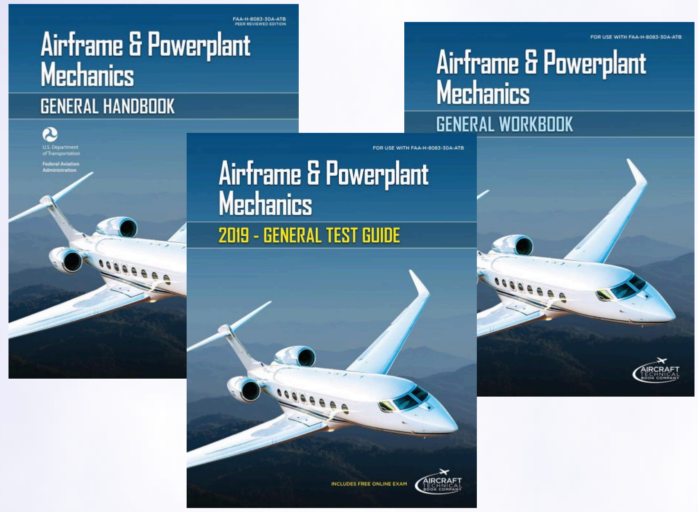

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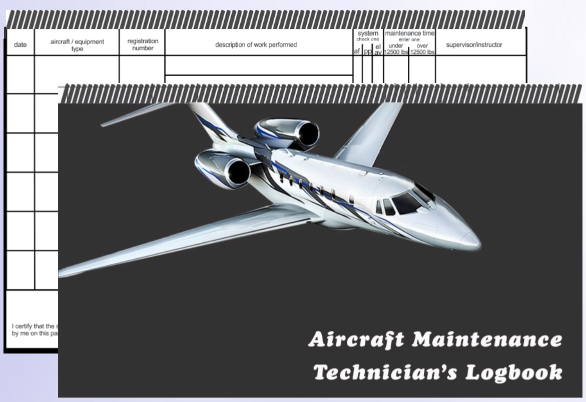

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- Younger maintenance personnel are bored with traditional classroom techniques.
- Are there better ways of representing real life, with its social fabric, randomness, variability, and decision-prompting crossroads in our computer-based HF training?

A number of discrete technology solutions are emerging that, if combined, could change the way we offer HF/CRM training.

Apart from references to International Civil Aviation Organization (ICAO), associated regulatory material, and specific websites hyperlinked in the text, this article is the personal opinion of the author.

INTRODUCTION

We are well-practiced at condensing 115 years of powered aviation history, with its good and bad examples of human performance, typically using past incidents and accidents as case studies, lessons learned the hard way.

But, if you are an experienced Human Factors (HF) instructor, have you ever wished we had a pool of new and different case studies? Of course, we do not want another Tenerife or Aloha accident to happen just so we have another epic case study to use in our training courses and reinforce our HF theory. But a method of generating additional, significant, but fictional, case studies can prevent the foundation case studies from being overused.

Throughout history, technology solutions for training have sought to enhance the value and the efficiency of our instruction. Virtual reality (VR) is the next technology to provide a means of combining the best of real life, the immersive experience, with the targeted learning focus that comes with rigorous instructional design.

It is sometimes easy to be caught in the hype of new technologies, and the promise that they bring to our work. How often has the next big thing turned into just another flash in the pan? But, leveraging the investment made into gameplay techniques, four recent technology advances in VR have the chance to come together and change the way complex training is conducted, like no other time in recent memory.

Coupled with ever-improving connectivity, Internet speeds, and cost of hardware, are we witnessing a perfect storm of evolving technology and gameplay design that could replicate real world interaction and forever transform how online technical and non-technical training is conducted?

Will these four developing aspects of virtual training cause a seismic shift, or just a ripple? I, for one, am earthquake-proofing.

REAL LIFE IS TOO SLOW!

Who does not love a good discussion about prescriptive training times versus a competency-based approach?

Like the aviation regulators, I like to keep my options open and have views in both camps. Some people may say that anybody can be trained and become competent in any skill, if they get enough real-world experience. But we all know, training needs to be more efficient than this.

Tarzan and Mowgli both grew up in the jungle, with lots of real-world experience. By the time they reached adulthood, there was nobody better equipped to live in the jungle.

So, does that mean everyone needs 18 years to learn how to live in the jungle? Not really. It just means that, over 18 years, the trainees have done enough interesting things to make them competent. If all the interesting things were condensed, their competence would logically be achieved more rapidly.

But, conversely, we do not allow first year medical students to conduct brain surgery. They may be able to display some competence in practical tasks, but we do not expect them to have enough experience to do it properly. We ask most aviation trainees, sometimes in a highly prescriptive way, sometimes with more flexibility for gifted people, to spend a set period as a trainee and to master certain practical and theory challenges before being deemed competent.

The premise of time on the job = well-trained depends on too many variables, is not efficient and most often advocated by people who were trained a certain way in the past and believe that way to be the best way. And, while real-life experience is essential, no one believes that the best way to train someone in HF principles is to exclusively use the real world and all the good things and bad things about human performance in the real world. There are not enough years in a person's lifetime to experience all those good and bad scenarios and learn from them.

INSTRUCTIONAL DESIGN AND TECHNOLOGY MAKES TRAINING BETTER THAN REAL LIFE

Any prescriptive training time requirement can nearly always be improved if enough care is taken with training design. With good training materials, we condense real life, concentrating on the interesting stuff and leaving out the boring times in-between. We take the best things from real life, then improve on them.

In good HF training, we supplement trainee's own real-world experiences by giving them targeted case studies and role plays and past incidents/accidents to examine. Robust instructional design seeks to emphasise the critical aspects and make training more time-efficient, comprehensive, and relevant to the job role.

A conclusion, then, is well-constructed HF training is better than real life! A lifetime of experiences and 115 years of industry history can be condensed into a succinct package, providing good and bad examples for teamwork, time management, communication, decision-making, and any number of other human strengths and fallibilities.

Technology solutions for training also have the ability to further enhance these experiences and multiply this efficiency. Even the most basic PowerPoint presentation is an example of someone condensing what trainees need to know. The proliferation of death by PowerPoint examples points to the fact that the obverse-leaving out what trainees do not need to know-is not done well!

Simulation techniques are an example of technology solution providing a quantum leap in training efficiency. The point of operating a simulator is to experience non-normal situations that rarely occur in real life. It is a way of conditioning people and developing competence so that they may deal with all possible experiences.

The same is true for VR, augmented reality (AR) and mixed reality (MR) methods. While VR designers can replicate the real-world experience in an active and immersive way, VR must offer a condensed experience, enhancing the real world by generating challenging scenarios, forcing things to happen, guiding and coaching, then insisting on reflection, self-analysis and response.

In my opinion, because of its immersive and engaging nature, VR has the potential to rapidly improve the way training, both technical and non-technical, is conducted. Some recent developments are showing that modern VR technologies are becoming even better for creating and managing training experiences. They are doing this in the following ways:

- Techniques for facilitating immersive, online social interaction for meaningful training purposes;
- Infinite variability in scenario generation, driven by algorithm, rather than design effort;
- Branching pathways that demand analysis and decision-making and that influence downstream experiences;
- The potential for introducing artificial intelligence, so that complex human interaction does not have to be with a real person.

This paper discusses these four design criteria, their current use in mainstream virtual reality, and their potential meaning for aviation CRM and HF training.

HF TRAINING FOR MAINTENANCE NEEDS IMPROVEMENT

Aviation regulators encourage regular CRM and HF training. People need to be periodically reminded of its importance and their own inherent fallibility. But a disruptive, possibly sacrilegious, question to consider is:

"Under what circumstances would you consider the 1977 Pan Am/KLM Tenerife accident to be a poor choice for a Human Factors case study?"

My answer is:
"When we bring it out of its closet and rehash it to the same people, the same way, every 2 years."

In the case of HF for aircraft maintenance personnel, the International Civil Aviation Organization (ICAO, 2003) makes recommendations, embodied in, for example, Civil Aviation Safety Authority of Australia (CASA, 2015) Part 145 (and also embodied by other National Airworthiness Authorities), that HF refresher training for Maintenance and Repair Organization (MRO) employees is to occur regularly in order for key staff to maintain their currency and hence their continuation as an approved employee.

While these recommendations are noble and are designed to regularly reinforce HF concepts to this important demographic of the aviation workforce, the conduct of much HF refresher training in Europe and Australia has become lazy, designed and sold by unscrupulous training providers, uses similar or even identical courseware for the Initial and Recurrency training. This forces experienced people to sit through the same presentation with the same points and the same conclusions every two years. There are parallel stories from flight operations trainers. The CRM side of the industry is sometimes just as guilty.

This situation is obviously counterproductive and reduces the impact and effectiveness of the worst accident in aviation history. I've heard participants saying, in effect, "Tenerife ... ho hum. Aloha ... *snore*. British Airways BAC1-11 windscreen ... yeah, yeah." It is a vicious cycle. Tenerife and these other examples were game-changing events. Like all those hard and tragic lessons learned from aviation history, they have prompted procedural change and vast improvements in our industry. So, of course, we need to use them in our training material. They are the best real-world examples and they are still a smack-in-the-face for new people in our business. There is nothing better to drive home the message of working in a safety-critical industry. But, for experienced people, the over-use of these case studies is degrading their shock value and their effectiveness. People are becoming bored with the way they have become ubiquitous within HF training material.

The purpose of the HF refresher is, of course, not to rehash the same points again and again. It is meant to include fresh information, hopefully customized to each organization, aligned with their Safety Management System and reporting culture. But, in many organizations, the HF refresher has evolved into a check-in-the-box exercise, something to get out of the way as quickly and cheaply as possible, to keep MRO employees on the job. Training organizations react to this demand, and spend as little as possible developing, maintaining and delivering the courseware, so that the price may be kept to a minimum. This attitude is a disservice to our industry.

If we want to keep our experienced HF training participants awake, we need to change the game.

SOMETIMES KIDS STRUGGLE TO APPRECIATE HISTORY

HF should have a timeless relevance to all aviation employees, but it has an undeniable historical element to it. All the landmark accidents that have contributed to big improvements in our industry, leaps in safety and efficiency, are in the past. Incidents and accidents still happen, inevitably and regrettably, and still contribute to incremental improvements in aviation systems, communication, and procedure. We still, of course, learn from new incidents. But, it is now technological improvements that are driving most of the marginal advances in safety. As the industry and its equipment become more reliable, accidents are far less likely to be game-changing lessons learned, in the same manner as Tenerife and Aloha.

The Tenerife accident occurred when I was in high school. It influenced my career path. CRM and HF training evolved during my aviation career. I appreciate that it has improved the way we work. I understand the need for it, and I am an advocate. I'm the converted. But what happens when we preach to younger generations?

First the good news. Younger people, I believe, are more open to an inherent appreciation of human performance, interaction, and limitations, including self-reflection and self-improvement. But they have been engaged and entertained in their learning from an early age. They need stimulus. This is not good or bad and is not a comment or judgement on whether they exhibit short attention spans! But it makes it incumbent on us, older trainers and instructional designers, to change. Keep up, comrades! The old ways are becoming less effective. We need to find different ways of conveying the important HF messages.

Many children of the 1950s, 60s, and 70s considered the stories and lessons of World War 2 history to be intensely boring and irrelevant for them, mainly because it represented their parents' generation, which was something they were actively rebelling against. Over time, younger people sometimes mature enough to get to see the wisdom of their parents and grandparents. They find an appreciation of the things that were important to the older generations. But, in the meantime, even subconsciously, many young people resist old opinions, old descriptions, old information.

With this natural rebellion of younger generations, I believe it is incumbent on us, as HF practitioners, to find ways to engage the younger people with the same HF messages, but to not fixate on Tenerife and Aloha (et al.). In effect, we need to tell the same lessons with different stories, or in a different way. Perhaps we need to learn some of the methods that museums and documentary makers and history professors use to excite younger generations about historical facts by creating engaging exhibitions and multimedia presentations. If we do that, the old case studies will remain smack-in-the-face and relevant, and not crusty old black and white photos and hand-drawn site maps.

Some significant advances have been made over the last few years in terms of gamified solutions for HF and CRM training. These boundaries need to keep expanding. Younger digital natives are coming into our industry having experienced online game-playing, tablet apps, VR, and AR for both leisure and learning. We cannot ignore this change in demographic.

If we want to keep our less-experienced HF training participants awake, we need to change the game.

WHAT IS ALL THE FUSS ABOUT VIRTUAL REALITY?

Obsessing about the latest, shiny technology to be used for training can be counterproductive. The latest tool is not automatically the best thing to use for any given training event. It requires a careful analysis of the resource alternatives that are available, plus the audience, the budget and many other considerations.

Far better for training professionals to remain focused on

learning outcomes, what trainees need to know and do at the conclusion of the training, rather than be distracted by the secondary matter of what is the latest and greatest tool.

But, just like in life, resources and options are important. Some delivery methods are better suited to certain subject matter. Sometimes a whiteboard and a marker are the best tools to use but, in other cases, the whiteboard and marker is not good enough.

Alternative realities such as VR, AR, and MR are rapidly gaining popularity as some of the latest tools to emerge in the training design space.

In my opinion, the value of VR, AR, and MR fits exactly with our obligation to modernize HF training for safety-critical industries. That is, we need to replicate the real world and create an immersive experience, but we need to condense real world events into a succinct training package. Then, importantly, we need to engage the kids and avoid disengaging the experienced people who need to regularly refresh their HF knowledge.

These requirements demand innovative approaches. One of these approaches may lie with these emerging technologies and lateral thinking in instructional design.

I am not advocating spending lots of money designing VR training materials just to entertain the younger generations. They have more than enough to entertain them already! But it is not hard to find consensus in this target group. Ask a bunch of millennials whether they would rather sit in a classroom for a day, listening to an instructor plodding through a PowerPoint presentation, or would they rather use their tablets or phones for a mixed reality experience, or pull on a VR headset? I can guess easily what the preference would be.

VIRTUAL REALITY FOR TRAINING

Some people had serious doubts about whether VR, AR, and MR would gain traction into widespread use, apart from games and real estate marketing. But there is no denying the investment that is pouring into these methods is expanding their reach and ensuring their longevity. Alternative realities have infiltrated some of the most conservative industries and are injecting life into them. Some sophisticated and serious VR and AR technical training products for aviation were emerging from the military and Original Equipment Manufacturers (OEMs) perhaps 3 years ago.

Of course, a full flight simulator and the less complex family of static training devices and replica cockpits are a form of virtual reality, and aviation was one of the first industries to really exploit the idea of simulation.

One definition of VR insists that it creates an experience that is not possible in physical reality. But I, and many other commentators, disagree. I believe there is firm application for VR in replicating real life. If a flight simulator is a de-facto virtual environment, then simulator manufacturers go to great lengths to ensure that their device accurately replicates the real world, both inside and outside the cockpit.

Alternative reality techniques can most certainly create an experience of an aircraft that is not possible in the real world, for example a semi-transparent and slow-motion gas turbine engine that is operating at full thrust. But some of the most powerful applications of alternative reality technology will be where the virtual environment mirrors the real world. Like a flight simulator, the virtual environment can provide the platform for the trainee to experience dangerous things safely, to perform complex things with guidance and incremental simplicity, and do expensive things relatively inexpensively.

FOUR GAME-CHANGING TECHNOLOGY ADVANCES IN VR

My interest in virtual environments started with the notion that a replication of the real world was an ideal place for trainees to gain confidence in a dangerous and busy airport environment. I saw these techniques as a new way to build skills in engineering and ground handling tasks without risk of injury or expensive damage. I saw a virtual environment as a familiarisation tool, never meant to replace the real world, only to supplement the real-world experience that trainees must still complete to be truly competent.

While investigating the variety of practical skills that may gain value from being duplicated in a virtual environment, it became apparent that the HF considerations of the real world were also undeniably relevant to gameplay in the virtual world. That is, apart from some of the unpleasant aspects of the physical environment that could be excluded from a virtual space (noise, fumes, heat, cold, etc.), nearly every other HF aspect had a relevance in the virtual space, including situational awareness, decision-making, communication, teamwork, leadership.

So, while I am still very interested in the promise of VR and AR to build technical skill, my focus has shifted to include concurrent research for the non-technical. I believe creating a comprehensive gamified virtual environment for HF training is certainly achievable. Plus, questions around the training value of the VR environment, and issues around gamification techniques and fidelity of the VR environment would supply many potential research questions for post-graduate research projects, for the HF academics, educational specialists and digital media experts.

Until recently, there were very few touchstones in virtual development that could guide the way for new and novel experiences in HF training. 3D modelling and game play techniques have progressed to a very sophisticated level, thanks to the gaming community. With enough 3D graphic firepower, we can certainly replicate a real-life aviation environment. From there, constructing ways of gamifying portions of our HF and CRM syllabus will be the instructional design challenge. Techniques to condense and improve the real-world experience have not, until recently, been immediately obvious. Now I believe they are emerging fast, and I have listed the most promising of them here.

1. TECHNIQUES FOR FACILITATING SOCIAL INTERACTION FOR MEANINGFUL TRAINING PURPOSES

To create an immersive and interactive virtual environment for HF training, the first step is to devise a way of getting people together in the one place, to interact in a way that at least resembles real life. The physical parameters of the online environment will dictate what sort of training tasks will be able to be achieved.

In the mid-2000s, an online game called Second Life http://secondlife.com/ was created and became very popular. Second Life is still operating, although its popularity has waned. Second Life was not the only place for social interaction online, but it was ground-breaking in the sense that it was one of the first sites where people created a community. Users had their own avatar, owned property and either built their own resources (houses, furniture, clothes, etc.) or could buy them from vendors. These vendors were graphic artists who created an inventory of objects and models, and made money making and selling 3D assets so that users could improve their (second) life. Second Life had its own currency for use in the virtual environment, but that also had an exchange rate against real-world currencies, a forerunner of today's cryptocurrency and alt currency boom.

Online commerce became popular in Second Life. Real-world businesses could, and did, create a corporate presence and could advertise real-world goods and also created replica goods for Second Life avatars to use. Some museums and art galleries established Second Life replicas, where people took their avatars to view the same objects they would find in the real-world institution. The site was used by history and geography students. Concert venues recreated their performance space and began hosting simulcast concerts.

People communicated in Second Life, albeit in old style keyboard chat. But avatars could crudely interact with each other. Some innovative real-world companies held training events in Second Life, where employees or students logged in and took their avatars to wherever the training was being held. This was an interesting variation on the teleconference/webinar that was also gaining popularity. A geographically dispersed real life workforce could sit their avatars around a table, or a lake, and view a video or listen to a speaker and also chat at the same time.

The history lesson is only important to explain that the concept of Second Life has, of course, evolved to accommodate the VR age. Newer variations of the Second Life bare environment, like High Fidelity (https://highfidelity.com/), allow individuals or organizations to create their own virtual space and explore other spaces created by other people. Like Second Life, there is a strong marketplace and commerce element to the site. VR graphic artists create VR assets that people can purchase or license from a kind of library that is expanding all the time. If a user purchases a 3D VR model, it can be imported it their own VR environment.

These sites are a new way for an organization to create their own virtual space for human interaction. Like Second Life, people can log in from anywhere at any time and congregate and interact. They allow a social VR experience that may be useful for intra-organizational purposes (for example, staff training opportunities), extra-organizational purposes (for example, between business and customers) or other forms of interaction and collaboration. Communication is now managed by sound, so speech between avatars is the standard, just like in a real-world scenario.

These sites provide the basic platform, scaleable to the size of your project. But they also provide more than a blank slate. They are becoming a content marketplace where you can find assets to purchase or arrange customized 3D development to your specifications. Once your basic environment is underway, people can log in from home, or from wherever they are in the world.

2. INFINITE VARIABILITY IN SCENARIO GENERATION, DRIVEN BY ALGORITHM, RATHER THAN DESIGN EFFORT

A deficiency of many online training scenarios is that every participant does exactly the same tasks. In some training settings, this may be appropriate, for example if the task has only a right or wrong way of doing it, and all people need to get it right before moving on to something more complex. But, online challenges quickly become less challenging when the correct solution becomes common knowledge in a workforce. Just as online examination banks now have randomisation of questions and responses, online training scenarios would benefit enormously from variability in the environment, the task, and the resources available to the participant. How may we do this without spending lots of money designing and building different scenes?

The gaming community has devised the answer, called procedural generation, whereby a game's landscape is generated not by artists or modellers, but by algorithm. Perhaps most famously, Minecraft (https://minecraft.net/en-us/) creates a unique world for each of its players, arranging landscape and creatures from a limited palette of bricks whenever someone begins a new game. But other infinite games like No Man's Sky (https://www.nomanssky.com/) is far more complex and sophisticated. While No Man's Sky failed to live up to its pre-release hype, the way the game is capable of generating tens of millions of unique planets that make up its gameplay universe represents a significant advance in programming technique. In No Man's Sky each planet in its universe is generated when a player discovers it, with different landscapes, different vegetation and animals, even different physics and challenges to overcome, making the game almost infinitely variable and specific to each player.

To extrapolate this to an HF/CRM training scenario, with a game constructed with a similar infinite variability, subtle differences could be achieved every time the same person enters the same room, or when another person enters the same room. This allows the gameplay to be unique every time. If everyone had a slightly different scenario, they could not confer with others about their particular task (unless this is encouraged). A person could conduct an exercise multiple times, if they are assessed as requiring more practice. The same behavioural markers can be tested, but the scenario will be slightly, or distinctly, different. The basic gameplay and then the variations that are possible between scenarios would all be governed by instructional design, allowing the needs of the training program to dictate the level of variability and who gets what.

3. BRANCHING PATHWAYS THAT DEMAND ANALYSIS AND DECISION-MAKING AND THAT INFLUENCE DOWNSTREAM EXPERIENCES

Related to the previous point of infinite variability is the notion that replicating real life involves giving people decision points, crossroads, where decisions or navigation selections need to be made. And, sometimes, the decisions made at these points are neither right nor wrong-they are decisions made using variable criteria, random circumstance, just like in real life.

Branching scenarios are again nothing new. We can even create them in PowerPoint! But to replicate real life, we need a large number of crossroads and choices, with the choices being trackable to give a more complete indication of a person's decision-making style during the game. This again encourages uniqueness when multiple players are attempting the same training or assessment task. Essentially, there is no single, correct path through a gameplay scenario. Each participant will make different choices, complex and simple decisions, each decision leading down a particular branching pathway to a different outcome. All these outcomes are valid, not right or wrong, just different.

This type of fluidity in progression through a training scenario quite obviously lends itself to HF, CRM, Non-Technical Skills (NTS) and other soft skills training, rather than the purely technical. In technical training it is often more obvious that a choice that deviates from what is expected, is a wrong choice. However, technical troubleshooting manuals and troubleshooting techniques where people must extrapolate their basic knowledge and interpret diagnostic information, quite often exploit a type of branching. But their purpose is usually to arrive at a singular conclusion-to confirm something as being correct or incorrect. In less technical training, there is often no need to get to a single conclusion, more to display a set of behavioral markers along the way.

An example of a recent computer game that exploits branching scenarios is The Stanley Parable (https://www.stanleyparable.com/). In this game, players are presented with the outline of a story, which then splits off in numerous possibilities, based on the player's choices.

As the story progresses with the free choices made by each player, there may be prompts for the player to return to an ideal path, but this is completely optional. The game itself is thought-provoking about the nature of independent choice and decision-making that influences what happens later in the game, the downstream experience.

With any proposed VR HF/CRM training game, the possibility of almost unlimited branching, so that there is no single (or two, or ten) correct ways of progressing through the training, makes the potential gameplay much more interesting, challenging, and reflective of the real world. Decisions during the gameplay will contribute not only to game success, but they become stealthy assessment tasks to assess real-life competency skills, knowledge, attitudes, and ethics. As players interact with each other, communicate, and collaborate to solve problems, tracking can be used so that each step, each interaction and each decision that happens in the game contributes to each player's assessment.

Consider also, if player movement and decisions are tracked to contribute to competency assessment, and if the game play involves many people, possibly from many organizations, the data gathered from the game could prove very valuable in terms of analysing a population and their decision-making under certain criteria.

4. THE POTENTIAL FOR INTRODUCING ARTIFICIAL INTELLIGENCE, SO THAT COMPLEX HUMAN INTERACTION DOES NOT HAVE TO BE WITH A REAL PERSON

Coupled with the technologies described here, that are all available in some form right now, is the probability in the future that artificial intelligence (AI) could be used to create and control random players for trainees to interact with.

The advancement of AI is less certain, but it appears more and more obvious as AI becomes more ubiquitous in our world. The advantage of AI in VR training situations would be obvious. If, for example, a VR game is devised for HF/CRM training that requires multiple players interacting, communicating, and collaborating. The multiple player element becomes essential but depends on a synchronous availability of people to play the game. What happens then if only one person is available? Or if three people are logged in, but the game is best played with ten? This is where the future possibility of AI would be able to take over the roles of the missing people. The artificial entities would be programmed with different personality traits, perhaps fashioned after the 16 broad Myers-Briggs type indicators, so that the AI communication and decision-making mirrors that of a diverse population.

While the possibility of AI helping to drive our HF training is a fair way distant in the future, I believe it is something important to consider. The use of AI would remove a barrier that exists even now. The best HF/CRM training is delivered so that it encourages discussions, sharing personal experiences, and inspires a diverse range of opinions. It is never ideal to conduct HF/CRM training with just one person.

CONCLUSION

We do not need to migrate all our HF/CRM/NTS training into a virtual/augmented/mixed reality format immediately. But the promise of VR, AR, and MR, as evidenced by the accelerating worldwide investment, is that these technologies are here to stay and will become more powerful and more pervasive as time goes on.

Face-to-face training or self-paced online learning will still exist as options for conveying information. The game-playing opportunities that have already been developed for HF training by various companies will not be lost. But, eventually, everything we do now will be able to be achieved in an alternative reality environment, with better fidelity, better immersion, and engagement, if we choose to adopt it.

Is variability and interactivity necessary for robust and effective non-technical skills training? Most definitely. That is what we strive for now.

Are younger technicians bored with PowerPoint and spending days in a classroom? Undoubtedly.

Are we failing our experienced technicians by forcing them to study the same HF case studies every two years? Absolutely.

Should we be looking for new ways of engaging younger staff and not letting the old lessons become stale? Most certainly.

Should we be proud of the advances that have been made in HF training for maintenance technicians and other MRO staff? Of course!

As any HF practitioner knows, a prescient phrase to use when trying to combat complacency is "promote constructive worrying." So, let us keep active and look for improvement. Let us worry, constructively, about these questions, and how the current methods may continue to be challenged. We owe it to the industry that has taught us so much over the past 115 years.

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