> “…what I’ve noticed over the years is that…the grasp of fundamental engineering knowledge and skills has eroded…”

The importance of teaching and learning fundamental skills

Brett Stewart, J.D., risk manager at AXA XL, recently spoke with Jonathan Jones, P.E., P.H., D.WRE, of Wright Water Engineers, Inc. and his son, United States Air Force pilot Capt. Ben Jones. The three discussed what they see as the lack of attention paid to fundamentals in engineering and they drew an analogy to the aviation field. Their discussion, edited for length, follows:

Brett Stewart (to Jonathan Jones): You’ve expressed concern that fundamental engineering skills need to be more effectively taught at universities, learned by students, and then regularly applied when the students become practitioners. Tell us what you see happening.

Jonathan Jones: A lot has changed since I was licensed as an engineer in 1984. Technology has helped us become more efficient and productive in many ways. But what I noticed over the years is that, in some cases, the grasp of fundamental engineering knowledge and skills has eroded or never existed, and can be improved.

BS: Can you give me an example?

JJ: A recent example that captured the attention of the national news media was the February 2017 spillway failure at the Oroville Dam in California, at 770 feet the tallest dam in the U.S., that forced the evacuation of 180,000 people. I corresponded with John France [P.E., D.GE, D.WRE], who was the leader of the team that prepared the January 2018 “Independent Forensic Team Report: Oroville Dam Spillway Incident,” and he concurred that lack of knowledge and application of fundamentals contributed to the failure of this facility. He noted that the potential impact that the vulnerable geology that was left in place beneath the spillway would have on chute performance was not recognized, and that “current principles and understanding regarding spillway chute structural design and underdrain design were not fully recognized, either.” France observed that “this all goes along with a problem that our profession has, that it seems to sometimes learn and relearn the same lessons. The information is out there, but not accessed and assimilated.”

BS: Do others in your profession share this view?

JJ: Yes. Based on my limited research, this is common. I recently contacted senior staff at about a dozen different engineering firms around the U.S. and asked if they sometimes observe a lack of fundamental skills in their less-experienced engineers. The response was overwhelmingly yes, including limited experience with basic things like collecting field survey data, reading design/construction drawings, applying basic design equations, and knowing what’s happening on a construction site.

BS: What factors are contributing to this problem?

JJ: Engineering professors are already very pressed to adhere to prescribed curricula, and obviously they cannot shortchange the highly technical material that must be taught. Some professors haven’t spent significant time outside of academia and may not appreciate the common application of fundamentals to everyday projects. Students will naturally be drawn to advanced technology and will tend to view fundamental concepts as less interesting and perhaps even less important. Finally, practitioners may not master and routinely apply fundamentals because they didn’t learn them in the first

Continued

place, they're pressed for time, their staff is focused on high-caliber technology, or because the software they use looks so professional and has such visual appeal that it doesn't invite careful checking.

BS (to Ben Jones): I know there's been discussion about a lack of fundamentals and over-reliance on technology in general, and that this phenomenon occurs in professions outside the design industry, including aviation. What are your experiences as an Air Force fighter pilot and, previously, as a licensed civilian flight instructor?

Ben Jones: Many military and civilian aircraft are very technologically advanced. It takes definite skill to learn how to use this technology. However, in some schools, students are introduced to advanced technology before they understand fundamentals such as perception, decision-making, and stick-and-rudder flying. Good pilots must understand advanced technology, but only as a supplement to basic skills, not to cover up deficiencies in these skills.

BS: Overemphasis on advanced technology sounds reminiscent of the crash of Asiana 214, a flight that originated in Seoul, South Korea, and crashed on final approach to San Francisco International Airport in 2013.

BJ: At the time, Asiana Airlines trained heavily on automation, presumably in an effort to prevent accidents due to human error. But in their efforts to minimize human error, they failed to adequately teach core principles—stick-and-rudder skills and situational awareness. As a result, no one in the cockpit noticed anything was wrong until it was too late.

The pilot was very senior but had relatively little experience in a Boeing 777. As he attempted to make a visual landing in near-perfect weather, he failed to understand fully how the onboard computer worked and he set both engines to idle. The airspeed decayed rapidly below a safe approach speed, but no one else in the cockpit noticed what was an obvious problem. The aircraft impacted the seawall well short of the runway, resulting in three fatalities and a total loss of the airplane. The National Transportation and Safety Board concluded the cause of the accident was a mismanagement of the approach and inappropriate monitoring of the airspeed, and pointed to a number ofcontributing factors, including an over-reliance on automation.

BS: You raise a good point. So long as people are involved, we need to consider human factors—how people interact with machines and technology—and the fact that accidents tend to be defined by multiple failure points.

BJ: Correct. The Federal Aviation Administration commissioned a detailed study of human factors and how they can cause or contribute to aircraft disasters. The FAA came up with a list called the "Dirty Dozen"—12 categories of human factors that are responsible for 80 percent of all aircraft crashes. [See the sidebar, "Dirty Dozen," for the full list.]

Dirty Dozen

These are the 12 common causes of mistakes in the aviation workplace, as determined by the U.S. Federal Aviation Administration. As you can see, many of these may contribute to accidents and claims in the design and construction industry as well.

1. Lack of communication
2. Complacency
3. Lack of knowledge
4. Distractions
5. Lack of teamwork
6. Fatigue
7. Lack of resources
8. Pressure
9. Lack of assertiveness
10. Stress
11. Lack of awareness
12. Norms

To learn more, visit: https://www.faasafety.gov/files/gslac/library/documents/2012/Nov/71574/DirtyDozenWeb3.pdf

Continued

> “…practitioners may not master and routinely apply fundamentals because they didn’t learn them in the first place…”

BS: These human factors are exactly what the AXA XL Design Professional team focuses on. Among other things, we track non-technical causes of loss that correlate directly to human factors. In the current economic expansion, we’re already seeing an increase in claims arising from the Project Team Capabilities risk driver, particularly as it relates to inexperienced staff, and the failure to review designs as part of the Quality Management risk driver. In fact, Project Team Capabilities represents the second-highest risk driver in terms of claim severity.

JJ: According to your data, this risk driver captures a current uptick in claims caused or contributed to by a lack of experience. And when you overlay unrealistic design and construction schedules, this can add pressure, as design professionals move too quickly and make mistakes. Unfortunately, we sometimes see firms unable to catch these mistakes because of poor quality management. For example, there’s a procedure in place to catch mistakes, like a checklist, review by another engineer, or adherence to a QA/QC manual, but due to time constraints or an unwillingness to follow procedures, corners are cut, the review is never conducted, and the mistake isn’t caught.

BS: When I speak with firms, many admit to these shortcomings. There simply are not enough hours in the day.

BJ: The parallels between aviation and engineering are remarkable. In the military, we intentionally overtrain on fundamentals in order to mitigate the effect of human factors like pressure caused by time constraints, mission stress, fatigue, and exhaustion.

JJ: This is the same challenge in the engineering industry. It’s not enough to master the fundamentals in school. It requires continuous practice throughout one’s career.

BS: With the stress of trying to meet project deadlines with staff who are already operating at full capacity, how do firms find the time to not only train, but to return to a place where design professionals are focusing first and foremost on fundamentals?

JJ: From an engineering perspective, I think we should:

- Maintain regular communication with our friends in academia and encourage additional instruction of engineering fundamentals, including some guest instruction/seminars from practitioners.

Continued

This could include offering to provide co-op positions for students and providing "senior design" classes that allow the students to design an actual facility, working as a team with one or more outside entities.

- Manage growth. One of the best ways to promote work quality is to refuse to take on too much work, as it invites sloppiness and inattention to fundamentals.

- Spend more time vetting and checking references during the hiring process and ask the right questions in order to determine the applicant's knowledge of fundamentals. Anyone can ask an applicant if they have a specific skillset. But much more can be learned from an open-ended question like, "Describe a situation where you were unable to rely on technology and had to resort to your core training to solve a problem."

- Make a top-down commitment to training and quality with the understanding that not always maximizing billing potential will pay dividends in the long run.

- Provide constant training on fundamentals both for new hires and laterals, e.g., identify bad habits and address them.

BJ: These same principles carry over into flight training. From my experience as a civilian flight instructor and Air Force pilot, the following points resonated strongly in my training:

- A commitment to proper training. I was fortunate to have several more-experienced pilots who put a high value on fundamentals act as mentors. The owner of our instructor school was willing to fund additional training that was part of his operational overhead. While this training cost money upfront, and took instructors away from billable tasks, it resulted in better instructors in the long run.

- Dedicating specific uninterrupted time to focus on training. As an Air Force pilot, whenever we go through formal training or an upgrade program, all of our other job functions are deferred. While this can place an added burden on resources that are already limited, it allows the trainee to focus solely on the training at hand.

Brett Stewart may be contacted at brett.stewart@axaxl.com or 925 658 1344.

Questions/Comments

> "Some professors… may not appreciate the common application of fundamentals to everyday projects."

Published by the Design Professional unit of AXA XL
30 Ragsdale Drive, Suite 201
Monterey, CA 93940 USA
800 227 8533

CommuniqueUSA@axaxl.com I axaxl.com/dp

First Canadian Place, 100 King Street, Suite 3020
Toronto, ON M5X 1C9 Canada
800 820 2721 x8682

DesignProfessionalCAN@axaxl.com I axaxl.com/dp-ca