WEB VERSION
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Process Automation

Table of Contents Blurb: Greg McMillan has pioneered the ISA Mentor Program to take new engineers beyond academic learning so they gain real-world knowhow and insights into control and automation. Mentored protégés provide their candid thoughts about the industry and the mentoring program.

Fast Forward

- In the past, new engineers had the advantage of on-the-job mentors that no longer exist in companies.
- The ISA Mentor Program guides new engineers on the path to becoming professionals.
- In this article, mentored protégés provide candid thoughts on their experiences.

Head: Enabling new automation engineers
Deck: Draw on the experience of others in the ISA Mentor Program

By Danaca Jordan, Greg McMillan, Héctor Torres, and Hunter Vegas

Introductory remarks by Greg McMillan

As a result of the ISA Mentor Program, I have had the personal pleasure of seeing firsthand the enthusiasm and talent of new automation engineers. These engineers have incredible positive energy and computer skills. However, the challenges facing a person entering this profession are considerable. I had company training programs, technical presentations, in-house standards and best practice development, plant testing, a mentor resource of a dozen or more engineers, and time to develop skills, but these advantages are largely gone. When I started at Monsanto, I was immediately put in an intensive eight-week electrical and instrument (E&I) school. I spent most of the next six years on location. I gained the knowledge of extensive instrument testing at a large Texas plant. I then developed a unit operation lab for the school to provide hands-on experience of what it is like to control a distillation column and neutralizer. I worked on standards and best practices. In E&I section meetings, the director would get a hand count of who attended the local ISA meeting. I was encouraged to attend and write papers for the ISA technical conference each year. I was then given time to find process control improvement opportunities in the plants. All along the way, I had access to the best minds in automation and process control. I acquired quite a library of essential books by Béla Lipták, Bill Luyben, and Greg Shinskey. Today I wonder if the new automation engineer is given the time and technical knowledge to do a considerably more demanding job than what I faced when I started 44 years ago. Technology has advanced tremendously and the expertise required to learn new tools and to keep up with developments in diagnostics, networks, software, smart instrumentation, and standards is more than a job. What little "how to" information that does exist is spread over hundreds of publications and tens of

thousands of pages, with no guide as to what to even look for. The procedural and paperwork requirements for operation support and small projects can be a full-time job in itself, leading to little free time for reading and developing skills and innovative solutions. To get a closer view of how the new user is dealing with this change in the automation career, I presented questions to the coauthors. Here are the answers received from fellow mentor Hunter Vegas, protégé Héctor Torres, and protégée Danaca Jordan.

Answers to Key Questions by Hunter Vegas, Héctor Torres, and Danaca Jordan

(1) What are some of the biggest challenges facing new automation engineers?
Hunter: Figuring out where to start. Students are taught all kinds of stuff not used on the job – Laplace & Z transforms, four or five semesters of calculus/differential equations, and all kinds of wonderful theory. Almost none of it is applicable to what we actually do. So a fresh out of school engineer (newbie) is hired and given a simple project – say install a flowmeter and a valve, and they haven't the first clue where to start. There are hundreds of codes, regulations, company standards, etc., most of which is unintelligible to even seasoned engineers. How do you run wires, how do you pick a flowmeter, and what questions do you even ask to start? What is project management? I cannot imagine trying to get started without having a co-worker or mentor guiding me.

Héctor: New automation engineers are provided with theory and complex procedures and formulas with little or no practice at all on real cases where they can fully utilize what they are taught. Fourier series and Laplace transforms are only tedious mathematical problems to solve with large procedures whose results are not conveyed to real world. The student will only solve them mechanically without really understanding the application in the real world.

Professors have been teaching the same subject over the years; since they are giving the basics in control, they do not consider it important to provide recent knowledge and advancements. The knowledge is general and only to the point of what kind of control systems are out there and sometimes relying on what the book says, not on any real experience by the teachers.

The new engineer has to review and go through many bibliographies, and then try to understand and apply the information. With new projects and the stress of being new, there's often not enough time to even consider reading. Without the proper guidance as to where to look for sources of information or where a good starting point is, the newbie can get easily lost.

Danaca: Hunter's example about knowing where to start is one considerable challenge, but knowing where and whom to ask for help or clarifications is another. Many of us who were raised with Internet access and smart phones immediately go to the web for answers, which can lead to information overload and masses of marketing-biased technical articles. A mentor can help steer you toward practical starting points on new projects and often can recommend authors, journals, or even their own work to research.

Unlike a wiki, a mentor can also provide information on what has not worked well in the past so you don't repeat their failures.

(2) What have you had to learn to date?
Hunter: I'm an old guy – that list is too long for this format!

Héctor: I have had to drop what I thought I knew and start all over again. I had to learn about tuning and dynamics, as well as the newest PID features offered to help accomplish the desired objective. Also, when you work with the same equipment over the years, you can easily fall in a conformity rather than be willing to look for new techniques, features, equipment; a comfort zone that will only make you lose time and valuable knowledge and experience.

Danaca: Just during this mentorship, I learned about diagnosing bad valves, setting up a historian to capture loop data, how to determine when controllers are fighting each other, what anti-reset windup is (and why it was ruining my control), how to practically time a feed-forward signal, the benefits of using a VFD instead of a control valve, where to find automation standards, batch temperature control basics, and how to size and set up a control valve to limit leak-through. I also experienced sizing, wiring, installing, and troubleshooting a new flowmeter for one loop, which included an evening of YouTube videos on using a handheld to reset the meter's flow range. There many more learnings, of course, but those are some of my favorites.

(3) What do you expect to have to learn in the near future?
Hunter: My biggest issue is keeping current. The technology is changing very quickly. New instruments are being designed, new communication protocols are being introduced, and field devices are becoming more "computer like" with every generation. In addition to keeping up with everything new, I must keep my skills sharp with everything old! Even though the latest generation of instruments is being installed, there are probably ten or 15 *earlier* generations of instruments, DCS systems, and communication protocols that are still in operation and often must interface to the latest stuff. That is a lot to keep up with.

Héctor: I'm expecting to learn how to migrate my current DCS. I expect to understand and put into action best practices followed by those more experienced and avoid common pitfalls. This might also be something new engineers will face, since many old systems are still in the field. Vendors can be great allies because of their experience, but the automation engineers should be aware of common mistakes and best practices.

Danaca: It is difficult to discuss this without getting into specific projects, but I believe I am going to be digging into dynamic feedforward control next. I am also championing better alarm management practices at the plant, so I will soon be elbow deep in those standards to justify my proposed changes and time.

(4) What kind of skills does an automation engineer need?

Hunter: That isn't an easy question to answer. I would say the breadth of knowledge of an automation engineer is much wider than nearly any other engineering type. We must know computers, chemicals, mechanical, low-voltage electrical, occasionally high-voltage electrical, communications, etc. The breadth is so wide now that I find more and more automation engineers specializing in certain areas because they simply can't know everything. Some guys stick to the software/configuration end, others tend to the electrical designs and field devices, and still others tend to manage projects and really not get involved in the engineering much at all. Obviously, the person that has the skill set to span multiple areas and at least know enough to ask the right questions in all areas is worth the most to an employer. But it takes years and a lot of self-study on the part of the engineer to get to that level.

Héctor: My major points are that automation engineers:

- Need to be able to talk to the people in the plant and get along with them, especially with the operators, as they are the ones working with the process on a day-to-day basis. They know when the process behaves well and when there's an abnormal situation.
- Should know the basics of the tuning rules to effectively use auto-tuners and understand what these tools do and the results. Nowadays, the new control systems will have improved auto-tuners, releasing the automation engineer from the need of really understanding what is happening behind the scene. The focus can become more on how to adjust the tuning factors (e.g., lambda) or use PID features to meet process objectives.
- Need to know how to communicate results and link his/her work to key factors, such as unit cost, energy costs, etc.

Danaca: As Hunter mentioned, the breadth of possible technical skills is too wide to master everything, but a few personal skills will really improve performance. Specifically, we need strong communication skills to justify our work, to build support for our projects, and to clearly explain what we are attempting to do (and why) to operations. A knack for troubleshooting is necessary for engineering in general, but in automation it's best combined with a good eye for detail, as the tiniest instrument specification or misplaced wire can bring down an entire system. Most importantly, we need to sustain learning habits, as automation technology is advancing rapidly.

(5) What did you learn in college that you use on your job?

Hunter: I can honestly say that I use almost none of what I learned in college except the occasional ohms law and some simple physics. (I suppose I have run into Assembly and FORTRAN programming once or twice in my career but, needless to say, there isn't a big call for that!) If I had to pick something, I would say that I learned how to learn in college. I picked up the ability to quickly scan documents for the information I need, and I learned how to break things down into key concepts so that I understood the underlying physics of a problem. With that knowledge, I could generally come up with a solution.

Héctor: I cannot think of anything, maybe coding and reading small programs. As Hunter points out, college helps you develop logical thinking so you structure

information and come to a solution. In my earlier days, the learning of BASIC and QuickBASIC provided me with skills to code. In the end, a programming language is not as important as the skills needed to think logically; anyone can learn different programming languages but not everyone knows how to structure code.

Danaca: I learned a lot of nomenclature, process basics, and problem-solving methods in college that I use at work. Our group projects and presentations helped me with some of the soft skills I frequently need, like running meetings and public speaking. I may never use a differential equation again, but I did learn where to look if I need one again.

(6) What could be done by ISA and universities to provide the knowledge you need?
Hunter: I have actually offered to return to my university and give a presentation or teach a class that provided a taste of what an engineer actually does. I was flatly turned down. The head of the department cut me off and told me that they had put together the curriculum as they saw fit, and they were uninterested in hearing what I (or anyone from outside the college) had to say. I've offered to do presentations at a couple of local colleges and been met with equally frustrating responses (or simply no response at all). Ironically, I find that elementary and some middle school teachers are the most receptive to outside presentations, so I do a handful of science/engineering presentations to those classes every year. I've given up on the colleges. They know people will attend them regardless, so they truly have little incentive to change – especially in a weak economy where they are turning away students.

The one marketable thing ISA has is automation knowledge, and people need that knowledge. Companies are outsourcing and downsizing – large intercompany engineering staffs are rare (if non-existent). People are willing to pay for books, classes, and technical seminars.

Héctor: The first ISA Automation Week I attended was in 2011. I had no idea of what to expect or what to look for, and I was mainly focusing on attending the conferences. When going to the exhibition area, I found myself walking around sort of reluctant to approach the vendor's stands. My thinking? I did not want a speech of how great a product was and how many millions I would save if I installed it. This experience is similar to buying clothes. I do not want the salesperson on my back or pushing me around to buy. Now, however, my mentality has changed: I want to approach the vendor stands to know the most recent technology, the more recent advances, and what applications they focus on. That completely changed my expectation and my experience; I had the opportunity to learn what was out there, recent instrumentation, and more.

End users have to be given examples of applications where they are not pushed to buy a specific product but can focus on the solutions provided. ISA presentations need to be detailed to teach the audience to apply certain knowledge and techniques. The end user needs to feel they learned something in the end, not knowing that a product does this or that. I need to know and understand how to run a control loop performance assessment rather than knowing there's software that can tell me how well the control loop is working and if it is interacting with some others.

The end users' commitment is to get interested in the more recent advancements in the field, so they are tempted to visit exhibitors. The vendors' commitment is to get the end users up to date on the most recent advancements and, if possible, provide practical applications. I am not sure which of these two is more difficult to achieve.

Universities need to have laboratories where students learn basics in a practical way – learn where all those strange mathematical procedures are coming from and are used. Simulators and control examples, such as the ones provided by the ISA book *Control Loop Foundation*, are a good source for practicing.

Constant review of the education programs needs to be pursued to ensure old and unnecessary stuff is removed and new things are incorporated. Some professors might be in their comfort zone and reluctant to change or include new knowledge.

Universities need to get closer to different associations like ISA to form a common front; the universities need to know the real necessities of the industry and work toward better industry-needs-fitting-programs.

Danaca: My education background was chemical engineering, so there was not a strong focus on automation. We had a very theoretical course on controls, but I really needed a more general introduction to instruments and practical process control in addition to the idealistic transform problems. ISA could work with professors to provide industry-focused webinars or well-organized, easy-to-find, and searchable introductory articles.

(7) How did you find out about – and end up in – the automation profession?
Hunter: Like most automation engineers, I "ended up" there. I was an electrical engineer, and my first job involved building one-of-a-kind robotic welders and automated test rigs for a division that fabricated nuclear cores for aircraft carriers and submarines. Money was no object, and we built some amazing stuff. I transitioned from there to a large chemical plant that was just beginning a huge automation program. We replaced "wind powered" pneumatic panel boards with DCS controls even as the plants continued running. I happened to catch the cusp of fiber optics development, personal computers, and communication networks, so I have seen a lot of change in my lifetime.

Héctor: This is what I wanted to do since the beginning; actually, I got pulled by the idea of building robots, but that has not happened yet, and I really enjoy what I am doing right now. Maybe when I'm old I will try to build a simple robot. For the time being, I have so many interesting challenges in front of me and so many things I want to learn that I am postponing that dream to pursue others.

Danaca: In high school I was heavily involved with FIRST Robotics (Team 624!), but as a chemical engineering graduate, I started out in process engineering. When I moved to a smaller plant my responsibilities expanded, and I soon found myself working on DCS and batch programming, controls, and instrumentation in addition to the capital and process optimization projects I had been expecting. It has been a wonderful challenge to

learn and apply all these new skills, but I had a lot of questions. The ISA Mentor Program has been a great help with the transition to automation.

(8) How could knowledgeable ISA people become active mentors?
Hunter: I have enjoyed answering questions on Béla Lipták's "Ask the Experts" column. I also write in answers to many other similar columns in other magazines. If ISA could somehow utilize these folks and profit from it – see item 6 above – they could get much out of it.

Héctor: Mentors need to know what other experienced people are doing, the reasons why some of those people have decided to become mentors. The "sharing knowledge seed" needs to be spread and planted. They need to trust in people. Both parties need to know what the expectations are from each other so no disappointment takes place.

Danaca: The first step is to let someone know that you want to offer your experience and some of your time. This could be through a formal program like the ISA's, or informally through a discussion with a more inexperienced person at work or in your local ISA chapter. Let the person know if you have any ground rules, such as avoiding proprietary topics, and give them a way to contact you. Don't fall into the trap of trying to solve all your protégé's problems though; we learn the most when given a place to start and mistakes to avoid.

(9) What makes a good mentor?
Hunter: Someone who has been there, done that, and got the t-shirt. However, that person also needs to be able to explain things in terms that the protégé can understand, and they must have the desire to teach others. It takes time and patience to be a mentor, but it is neat to see your "protégés" grow and ultimately become good mentors.

Héctor: [A good mentor has]:

- Experience in the field
- Understanding that the mentor position does not mean "I have all the answers"
- A willingness to help the protégé rethink or consider another approach
- Patience, patience, patience; information might not be digested at the first, second, or third pass
- Understanding that an answer to simple questions to the mentor's optic represents a valuable piece of information to the protégé's growth
- Several questions can come from all flanks; the mentor needs to be really convinced of what he/she is doing or can get overwhelmed and buried by the tons of questions

Danaca: A good mentor has experiences to share, both good and bad. They can explain things in a couple of different ways when we are truly lost, and recognize when we can learn more from figuring out something ourselves.

(10) What kind of information do you need from books and articles?
Hunter: I'll let the others answer this one.

Héctor: Basically, publications providing theory of operation and plenty of examples of applications where a specific feature was implemented; examples with detailed explanation. Sometimes articles skip that part and [just] come to the conclusion, leaving the reader with many questions. If the final objective is to convey knowledge, let's cover all details. Also, those writing an article or a book should be open to questions – maybe not to solve specific cases but to provide guidance as needed.

Danaca: Add pictures! The best explanations at work all seem to involve a whiteboard, as the visuals really drive home the details and integrating components of a problem for me. Including drawings or diagrams with technical explanations really helps.

(11) How do you get your management to give you time for developing skills and developing ideas for process control improvement?
Hunter: One back-handed way is to acquire a certification – Professional Engineer, Licensed Electrical Contractor, ISA Certified Automation Professional (CAP), etc. Most companies love to have such people on their payroll; however, they don't realize that nearly all such certifications require continuing education credits. Since you have to have the continuing education to keep your certification current, there really is no choice but to allow you to attend whatever classes and conferences you want!

Héctor: I guess I am lucky in that sense. My manager always considers having three main objectives:

1. Safety: each member of the team needs to be seen as a precursor for safety, set an example, and care about others
2. Process improvement: have objectives to tackle operation and quality issues
3. Personal development: this includes projects that generate knowledge in the people and also convey value to the company, as the case of this ISA Mentor Program. This support helps in two ways: keeps the employee enthusiastic about learning and applying new knowledge, and, through it, helps the business to grow and improve operations. This in turn gets the employee recognition and generates a long-lasting relationship between both parties.

Danaca: I lean heavily on operations and maintenance to help me identify areas for control improvement. Since they run the equipment, they know where the trouble is and are supportive of efforts to fix those problems. For personal development, I stress the changing and dynamic technology to my management. Conferences, classes, and networking are needed to keep up with what is available and performing well for similar problems at other sites.

ABOUT THE AUTHORS

Danaca Jordan is a manufacturing staff engineer working for a specialty chemical company in the U.S. She began her journey to automation in high school as team captain for FIRST Robotics Team #624 and earned a BS in chemical engineering from the University of Houston in 2008. She strives to further automate and optimize batch logic and operations while managing a steady stream of capital improvements. Jordan is an

active member of AIChE and ISA and is a successful acolyte of the ISA Mentor Program.

Gregory K. McMillan is a retired Senior Fellow from Monsanto-Solutia and an ISA Fellow. McMillan received the ISA "Kermit Fischer Environmental" Award for pH control in 1991, the *Control* magazine "Engineer of the Year" Award for the Process Industry in 1994, was inducted into the Control "Process Automation Hall of Fame" in 2001, was honored by *InTech* in 2003 as one of the most influential innovators in automation, and received the ISA Life Achievement Award in 2010. McMillan is the author of numerous books on process control and has been the monthly "Control Talk" columnist for *Control* since 2002. He has a Control Talk blog at http://community.controlglobal.com/controltalkblog and provides posts on ISA Interchange at http://automation.isa.org/author/gregmcmillan/.

Héctor H. Torres is a senior process and control engineer at a plant in Mexico. He holds a BS in control engineering by the Autonomous University of Nuevo Leon (UANL) - Faculty of Mechanical and Electrical Engineering (FIME), and a MS in industrial engineering by the Puebla Technologic Institute (ITP); also holds a Certification as Six-Sigma Black Belt by the Monterrey Institute of Technology and Higher Education (ITESM) and the Breakthrough Management Group International (BMGI). Torres has 15+ years of experience in process and control engineering and has worked on many project teams. He has been an active participant in the ISA Mentor Program led by Greg McMillan since its inception in Oct 2011.

Hunter Vegas, P.E., holds a BSEE degree from Tulane University and an MBA from Wake Forest University. His job titles have included instrument engineer, production engineer, instrumentation group leader, principal automation engineer, and unit production manager. In 2001, he joined Avid Solutions, Inc. as an engineering manager and lead project engineer, where he works today. Vegas has executed nearly 2,000 instrumentation and control projects over his career, with budgets ranging from a few thousand to millions of dollars. He is proficient in field instrumentation sizing and selection, safety interlock design, electrical design, advanced control strategy, and numerous control system hardware and software platforms. He has also recently co-authored the book, *101 Tips to a Successful Automation Career*.