

What Skills Do Controls Engineering Graduates Need for Success? A Panel Discussion from the 2008 American Control Conference

Are universities creating the controls engineers that industries need?

Recently, engineering education company Quanser and The MathWorks hosted a lively 90-minute open panel discussion on this topic at the American Control Conference in Seattle, Washington. The panel included accomplished academics and senior leaders of industry: YangQuan Chen, Associate Professor at the Electrical and Computer Engineering Department of Utah State University; Bozena Pasik-Duncan, Professor of Mathematics at the Department of Mathematics of the Kansas University; Kevin A. Wise, Senior Technical Fellow from Boeing Integrated Defence Systems; Michael Moan from Raytheon's Intelligence and Information Systems Division; Jacob Apkarian, Founder and CTO of Quanser; Andrzej Banaszuk United Technologies Research Center Fellow and Greg Stewart, Control Engineering Research and Development Fellow at Honeywell.

With all this brainpower, there was much banter, with discussion of many educational and industry trends. There was near consensus on the need for more interdisciplinary learning and training, and some discussion about specific technical needs or challenges. The panellists conveyed a great deal of passion and concern for the future of engineering education. During the event, several important themes emerged, highlighted beneath, and were continually revisited.

Old theories, new practices or both?

Host Rohit Shenoy from The MathWorks, began the debate, inviting opinions regarding the evolution of academic curricula. Given modern computing power, should universities teach 'the latest and greatest techniques', such as H-Infinity and Model-Predictive Control? Or should they stick to industry-accepted techniques such as PID Control? Even after this topic was closed, discussion slid back to this topic, in different forms, throughout the 90 minutes.

The answer, simply put, was both. Yes, PID tuning, or the ability to apply basic techniques effectively, is a crucial skill, but knowledge of advanced control techniques is also needed. Panellists wanted students to learn the theory behind advanced techniques, but also learn practical things such as software tools, teamwork and communication skills. Theory cannot be ignored – skipping basic concepts or the relevant mathematics only leads to long-term engineering deficits. New technology should be taught where it is relevant to solving the problem or where it will help with efficiency. To illustrate this, Kevin Wise of Boeing noted that where students could once hope to complete perhaps two problems in a semester by writing

their own algorithms, now they can master up to ten by leveraging software tools like MATLAB. Yet, he rarely finds undergraduate students with the level of control theory knowledge that he seeks.

Systems have become more complex. Today, students require knowledge of multiple disciplines and complex multi-variable techniques. With so much to know, there's a temptation to ditch theory and just show students how to use the tools. Nobody agreed with this practice – they felt that teaching only software tools is limiting and of little use to the industry – tools knowledge is essential but needs to be taught alongside, not instead of, the core concepts

There was much agreement that students need to assimilate not just the theory *but also* advanced applications. As computers become more capable, we are going to expand that need. More skills are required for the modern controls engineer.

Greg Stewart and Kevin Wise who both also serve faculty roles pointed out that many of their junior colleagues rely on taking graduate courses while working full-time, to fill their need for advanced skills.

Critical thinking, intuition and teamwork

Several panel members talked about taking students deep into the basics while at the same time expanding other skills that at first don't seem as relevant. A subset of the panel bemoaned the disdain for basic mathematics among students. They all praised the development of teamwork.

Bozenna Pasik-Duncan, was particularly passionate: "From day one, in the classroom you need to put people in teams." In fact, she promotes mentoring roles for her graduate students with undergrads and would even like her teams to extend into high schools. She repeatedly discussed the need for adding excitement to undergraduate education to capture the imagination of the internet generation.

An observation on the panel was that the best prepared students have developed core skills like intuition and the ability to analyze a problem. They can "feel how things are done right," said Jacob Apkarian. Because it's a combination of intuition and knowledge that makes up a good engineer, he added.

Greg Stewart reinforced this point. While advanced techniques and tools are needed, intuition and knowledge of the basics are essential. Greg felt that unless you can tune a simple system well, you will not be successful. Intuition will help you identify the strategy to follow because in real-life nobody will say, "Please solve this Model-Predictive Control problem".

Big picture and communication skills

It's this need to grasp the fundamentals yet still be flexible – to cultivate softer skills like intuition – that led to a side discussion on the need for *big picture* thinking. Panelists mostly agreed that students have to understand the wider engineering problems from inception to implementation, a thought emphasized by Andrzej Banaszuk.

Also crucial is the ability to communicate. Nearly every member of the panel raised this point and more than one linked it to the controls engineer's role as the 'glue' on a given team. They need to be a jack-of-all-trades, comprehending the other engineers' disciplines and tasks almost as well as their own. Plus they need to communicate clearly with all members of the team.

YuangQuan Chen emphasized the big picture theme several times – and worried that debate could continue all night if they, and the students they're responsible for, don't agree first on a given experiment's details. He passionately stressed the need for teamwork, and multi-disciplinary controls engineers who convey their ideas with precision.

Multi-disciplinary learning

Industry panellists highlighted the need for multi-disciplinary skills in new graduates. As controls engineers work with engineers from other fields, physicists and mathematicians, it is important that groups can speak a common 'language' and that controls engineers understand the challenges faced by the other disciplines. Kevin Wise pointed out that this is especially true in small companies or groups where one team will perform all tasks from requirements gathering to finished prototype or even finished product. Greg Stewart backed this up with his own experience of working on all stages of product design within his group at Honeywell. Such environments require the ability to work in teams and communicate in languages beyond programming.

The future and the academic/industry divide

Most members agreed that a good way to prepare well-rounded students is through lab work – with its team interaction and application of theory. However, of concern to more panel members is the seeming divide between the needs of industry and the focus of universities. Students also share this perception.

Bozena Pasik-Duncan would love to see more industry representatives coming to the classes. She felt it helps excite the students and give them a taste of real-world engineering projects. Even better, others noted, would be more formal collaboration between universities and industry. Jacob Apkarian observed that interaction between industry and universities is

common in Canada. Many Canadian students participate in a program where they intern in engineering firms, alternating on-campus semesters with work. It takes them longer to complete their degrees but helps them gain valuable real-world experience.

The issue of lifelong learning also came up more than once. If there were programs or courses for continuous learning that practicing engineers could take, a panel member believed these would be very useful and popular. A couple of panel members shared the advice they give to young people considering a career in engineering: study something you'll still be using 50 years from now. Michael Moan observed that engineers "tend to work themselves out of a job." So it is important to constantly grow your skills because some skills become commodities.

Finally the panel members discussed what type of student makes a great controls engineer. Again, the themes of critical thinking and teamwork emerged. Everyone agreed that a positive attitude, enthusiasm and good communication skills were essential. Depth of knowledge in controls is the price of entry, a vital given, but the ability to analyze a problem and understand its implications is more important than a particular technical depth, and ultimately is what moves a career forward.

For more information about this panel discussion contact
Keith Blanchet • 1-905-940-3575 ext.459 • keith.blanchet@quanser.com
Rohit Shenoy • 1-508-647-7972 • rohit.shenoy@mathworks.com