

# **The ACE 2006 Invited Panel Session: RETHINKING CONTROL EDUCATION IN THE MODERN WORLD**

Organised by the IFAC TC on Control Education, and the IEEE - CSS Technical Committee on Education, this Session is aimed at stimulating discussion on numerous challenging questions that will influence the ways in which we will teach control topics in the future.

In an effort to make the discipline of control more attractive to students we often introduce this subject as an enabling technology in the context of embedded electronic systems, intelligent robots, mechatronic systems, advanced communication systems, space technology, etc. While this approach works well in promoting the field of control, it however raises numerous questions such as:

- a) how much of the advanced computing technology do we need to use in presenting the basic control topics?
- b) are we going to fall into the trap of being technology driven and thus, in the long term, start to lose analytical problem solving skills?
- c) are we about to change the way we teach control?
- d) are all of these approaches going to change the profile of the control discipline?

Do we need to worry about these changes or, maybe, even strongly support them? Do we need to have a new kind of control textbook to address new technologies? More and more people want to access innovative courses, preferably on-line. Do we need an on-line control course too?

Here is what the invited panelists Pedro Albertos, Derek Atherton, Sebastian Dormido, Bjarne Foss, Alberto Leva, Bozenna Pasik-Duncan, Christian Schmid have to say about the subject.

## Statements by the Panelists:

Pedro Albertos, Spain

Control engineering is strongly based on theoretical concepts and tools, but it also requires a lot of expertise and common sense. To teach control to beginners, most emphasis should be placed on the concepts and the use of mathematical support as a way to formalize them. Sometimes, basic control courses are planned the other way around and they start with a lot of formalisms, delaying any insight into the control problem till a later stage.

Current technology allows interactivity and ease of learning, but, again, major attention should be placed on concepts and, what is even more relevant, the range of validity of these concepts in real life applications. A modern basic control course should start with the control problem statement, its simplifications and models, solutions and analysis of the validity of these solutions.

Derek Atherton, U.K.

In my opinion most first courses in control spend far too long on the basic analytical tools such as, stability, frequency response plots and root loci and not enough time on the design of controllers to meet specific performance criteria. When control engineering courses were first taught in the late 50s, students used slide rules and logarithmic tables for calculations and no access to computers was possible. It was therefore necessary if one wanted, say, frequency response information to be able to sketch Bode diagrams and do calculations for plots. Today all this information is readily available from computer software both to students and also when they graduate and take up positions in industry. The challenge is to teach sufficient information to the students so that they understand the validity of computer plots and the information they contain, so that they can appreciate how to achieve a satisfactory design. Some methods of design such as optimisation often cannot be done without computers.

I believe what we teach is influenced far too much by the fact "that at the end of the day" it is easy to set examination questions on using these basic tools. Many students rightly regard this as mathematics and "are turned off the course". Plotting a root locus and selecting a gain to place, say two lightly damped poles at a certain location, is not a completed design for addressing a specification on a closed loop step response. Neglected poles or zeros may influence the assumed result and it may also be important to look at the magnitude of the control signal and the effect of parameter variations on the performance. Students can, of course, be given assignments using control software to cover these topics but here they can normally seek assistance, consult with other students, etc.; aspects which need to be encouraged for the purpose of developing team work. To evaluate their individual ability access to software needs to be available during the examination so that realistic problems can be set and design ability tested.

Sebastian Dormido, Spain

Computer-Aided Control System Design Software (CACSD) software has had a great impact on the practice of control system analysis and design. Since the 1970s there have been significant efforts to develop software packages for modeling, analysis and control system design.

Today Matlab and Simulink are the de-facto standards. We have all been experimenting for several years with the use of Matlab/Simulink and several of their toolboxes in our basic undergraduate control course. Now most of the control texts include a fair amount of Matlab but not serious use of CACSD software. In fact I have not found a textbook that really integrates computer aided design tools into the subject.

How does the easy availability of these tools change the syllabus? In my opinion there are two important changes. First, the amount of time spent to teach plotting of diagrams can be reduced. Second, the time spent on control system design, and on deeper aspects of control can be significantly increased. In this sense, I would like to

share with the audience information, start discussion and hopefully assist in the evolution of a consensus on how these new tools should change the curriculum in the future.

Bjarne Foss, Norway

Educational games, simulators and state-of-the-art visualization may create a new and improved learning culture by taking advantage of the knowledge and new skills of today's students obtained from extensive use of interactive games software. I believe that future educational resources should take advantage of this and will therefore elaborate on this during the panel discussion. I will also present the experience we have at the undergraduate level with this kind of educational resource.

Alberto Leva, Italy

The control engineering panorama reveals quite a widespread diffusion of a syndrome that one may call "designing one thing, and then implementing another". Too many implementation issues are treated as "coding incidentals", rather than being addressed theoretically. The availability of advanced computing technologies helps, but it also makes the above problem even more relevant.

If students were made aware of how methods are implemented as soon as possible, a rigorous way of addressing "practical" problems, and also a constructively critical attitude toward technology, would be promoted. This, in my opinion, is a challenge we need to take on in the near future.

Bozenna Pasik-Duncan, USA

Bozenna Pasik-Duncan organized the panel session on Math, Science and Technology in Control Engineering Education at the ECC/CDC'05 in Seville, Spain, last December with 12 panelists and she will organize Part ii of the session at the ACC'06 in June. While organizing these sessions she has been inspired by the ongoing national and international dialogue after some "alarming reports" have been issued in the United States. She would like to remind the audience that in July, 2005 a report signed by 15 prominent business leaders said we need to double the number of science, math and engineering graduates by the year 2015. In September 2005, IBM said it would back 100 employees financially to leave the company and become math and science teachers. In October 2005, the National Academy of Science, the National Academy of Engineering and the Institute of Medicine issued a report titled "Rising Above the Gathering Storm". It urged the nation to recruit 10,000 students to science and math teaching each year by creating scholarships. In return, program graduates would teach in public schools for five years. Some other morsels from that report: more than 600,000 engineers graduated from higher education institutions in China in 2004, 350,000 from India and 70,000 from the United States. She would like to address the following questions:

What should we, scientists and educators, do about cultivating student interest in science, math and engineering, in particular in control systems engineering?

Is it important for engineering students to know math and science

Should engineering education focus mostly on technology?

She will share the brief reports from those panel sessions as well as make some recommendations for cultivating student interest in science, math and engineering by encouraging the control community to better communicate the excitement, power and beauty of control systems together with math and science to the public, including kids in K through 12. Collectively we must develop understanding, look at relationships amongst things that influence our every day lives, the environment in which we now live, look at how to develop new products, new technology, new models, new applications in different disciplines, look at issues of health or economic well-being in new ways. She has been proud of the CSS Technical Committee on Control Education and the IFAC Committee on Control Education outreach programs for holding workshops for middle and high school students and teachers at every major CSS conference as well as at the IFAC conferences.

Christian Schmid, Germany

Technologies are the driving force of the world's communication. Technology offerings have increased dramatically in recent years. These advances have also introduced new educational nomenclature: "virtual education", "virtual labs", "remote labs", "virtual universities", "virtual" and "cyberspace institutions". Many educational institutions seem driven to use newly found access to global data communication that will increase enrolments and will award a vast range of degrees through massive investments in distance education programs. Despite ceaseless investments in emerging technologies by institutions of higher education, few questions have been raised as to whether these technologies are truly essential to support instructional and overall educational goals. If technological investments are imperative in acquiring productive learning tools, one must also ask, how can emerging technologies be effectively utilised to achieve optimal education? Those who govern the educational system tend to perceive the role of technology as the ultimate end, but nowhere do you find more enthusiasm for the god of technology than among educators.

From a general point of view, I think that technology in all forms, young and old or simple and complex, can be potent tools that engage learners in cognitive reflection. These tools engage learners in rethinking their old beliefs, knowledge and understandings. These tools might allow learners to compare new ideas with other individuals to assess whether new concepts and ideas are plausible and fruitful. Technologies can be educators' tools in finding creative ways that encourage students to self-test, self-question, and self-regulate learning in helping them to create solutions to complex problems. Changes in instructional design might integrate perspective theories, applications, and research related to learning, thinking, teaching, educating, integrating, mastering, and leading powerful technological advances. These changes may be used constructively to creatively lead the educational system to a brighter future and a more realistic information age.