Education, Instruction, and Motivation

Be not afraid of greatness: some are born great, some achieve greatness, and some have greatness thrust upon them.... Daylight and champaign discovers not more.

—William Shakespeare,
The Twelfth Night

Two of my side interests are history and language, and so it is not surprising that the history and origin of words are also passions of mine. The Latin word campus, meaning field, is of particular significance to me. Before spending virtually my entire professional career on college campuses, I grew up in the small town of Champion, Ohio, whose name derives from the word campus. In medieval times, a knight would go out into the field to fight for a cause, thereby becoming a "champion" of that cause. Since presumably the only way to remain in the field for long was to be victorious, the word came to be associated with the winner. I now live in Champaign, Illinois, whose name is also derived from the Latin word campus and means a flat open landscape. Anyone who has been to central Illinois can confirm that its flatness is "as obvious as daylight in an open field" or, as Shakespeare would say, "daylight and champaign discovers not more."

I am writing this message during "March Madness," the name given to the annual men's college basketball tournament in the United States. The University of Illinois "Fighting Illini," under the leadership of its second-year Head Coach Bruce Weber, has just completed its best season in the team's 100-year history with a 37-2 record, a Big-10 conference championship, and a second-place finish nationally. This success has me thinking about the similarities between teachers and coaches.

The word *teacher* emerged in the 13th century from the old English word *tæcan*, meaning to show or declare, similar to the modern German word *zeigen*, to show. The word *coach* derives from the old Hungarian town of Kocs, where the first carriages of that name were produced. The pedagogical and athletic sense of a coach as someone who "carries" a student or athlete to success came about in the 19th century. Interestingly enough, upon winning a championship, a successful coach is now often doused with champagne, itself named for the flat open region in France where it is produced, but I digress once more.

On the other hand, the word *instruction* derives from the Latin *struere* meaning "to pile or build," as in to create a "structure." Although we give people the job titles of coach and instructor, I find that these terms, together with the term teacher, do not adequately describe those who achieve the most success on the athletic field or in the classroom. Successful coaches do not "carry" their athletes to victory. Successful teachers do not simply "declare" the truth, nor do successful instructors " pile" knowledge into empty containers. Rather, the best coaches and the best teachers have two important attributes in common. They are motivators, and they are educators. The word motivate comes to English from Latin through old French *motiver* meaning "move to action." The word *educate* derives from the Latin *educatus* (*ex* + *ducere*) meaning to "lead" or "bring out." The best teachers and coaches bring out the best in other people by motivating those around them to succeed and by fostering an environment where others want to be and want to contribute.

How do teachers and coaches accomplish this? First, the best teachers and coaches love what they do, and they convey a boundless enthusiasm for their work. Such enthusiasm cannot fail to excite and motivate those around them. Second, teachers and coaches are outward rather than inward looking—that is, they rejoice in the success of others rather than covet their own individual success. Third, they set the highest standards and expectations for themselves and for others. Of course, one cannot lead anyone farther than one has himself gone. Therefore, the best coaches and teachers are, of necessity, technically brilliant and strive to keep up with the latest developments in their field. These ingredients of enthusiasm, interest in others, high expectations, and technical excellence lead to a positive feedback loop that facilitates the recruitment of the best and most talented people (students and faculty, athletes and coaches), who then subscribe to the very same traditions of

excellence. This feedback loop is why a disproportionate share of championship trophies are won by the same teams year after year and why the top universities continue to recruit the best faculty and students. Certainly, Coach Weber possesses these attributes in abundance, and I have seen them time and again in the top educators and researchers in our field. While it is possible to succeed with technical excellence alone, and sometimes even with enthusiasm alone, I believe that real greatness as a teacher or coach requires all four of these attributes.

How does one motivate students in control engineering? As one of the more mathematical engineering subdisciplines, control theory can be both intimidating and confusing to engineering students. For example, grasping the relationship between the frequency response of a system and its time-domain behavior requires considerable maturity and, in fact, often requires exposure to real systems. I have found that student projects are one of the best motivators for learning control theory and its relation to engineering design. The photo on page 10 shows two of our recent projects, the Segmonster and the Segbot, both of which were carried out (and named) by teams of undergraduate students at Illinois.

The Segbot, shown in the foreground, is an autonomous two-wheeled mobile robot that balances (using a rate gyro and inclinometer as sensors) and locomotes. The Segmonster, shown on the right with the cardboard head (that's me on the left just so there's no confusion!), is literally a robot that rides a Segway Human Transporter (HT). Of course, one can instrument the HT to make it autonomous; there's no real need to build a "robot to ride a robot" as one of my colleagues once joked. But, the real goals here are motivation and education. The motivation comes partly from the fun inherent in such "cool" projects but also from the challenge of building a robot to carry out a human task using only what is available to the human. In this case, the robot has to move its torso back and forth to balance and rotate the handle grip to steer just as a human does.

A decade ago, we employed this same challenge of designing the robot to work in the human environment rather than structuring the environment around the robot in the development of our air hockey playing robot. The education comes about from solving myriad practical problems that are difficult to teach in a classroom lecture setting. The problem of noise and the importance of shielding and good filtering algorithms come quickly to mind, but there are a host of other issues, including the sizing of motors and linkages, flexible shaft couplers, bearings, timing diagrams, and computer interrupts. I find that such things are better learned in a hands-on laboratory setting.

I am often asked by young research faculty what is the best way to achieve tenure. I believe that the same attributes of a successful coach or teacher that I described earlier are also present in the most successful research faculty. But especially important is the first attribute—to love what one does. I have seen a number of young people become obsessed with the metrics of tenure (the number of publications, the number of research grants received, and other statistics) and not only fail to enjoy their probationary periods as assistant professors but also fail to achieve tenure in the end. I advise colleagues, therefore, to focus on the work and ignore the metrics. If one's focus is on achieving excellence in an area that one loves and one sets high standards and expectations, then the metrics will usually be satisfied as a normal byproduct. I am sure the same can be said of winning championship trophies.

An illustrative example from my own career occurred more than ten years ago, when I approached a colleague and asked him to serve as the department representative on a committee being formed to create a college-wide undergraduate control systems laboratory. He refused, saying that such an activity "would not get him promoted." As a result, I took on the task myself, and it turned into one of the most enjoyable and rewarding experiences of my career. The College of Engineering Control Systems Laboratory at Illinois is now widely regarded as a role model for other universities to emulate. In fact, several of the devices that were developed (the pendubot, reaction wheel pendulum, and mechatronics controls kit) as part of that activity are now in use at universities around the world. I was not thinking about career advancement when I began this work, but it nevertheless has been professionally and personally rewarding for me. As Jeffrey Young says in his biography of Steven Jobs, "The journey is the reward." Oh, and by the way, the colleague who declined to participate in this activity is still an associate professor.

Society News

This message went to print before the June IEEE Control Systems Society (CSS) Board of Governors (BoG) meeting at the American Control Conference (ACC) in Portland, Oregon, and before the IEEE Technical Activities Board (TAB) meeting in Chantilly, Virginia. Therefore, I do not have much in the way of noteworthy news items to report at this time. I will inform you of any important items resulting from these meetings in my October President's Message.

I would just like to use this opportunity to remind members of the importance of voting in the CSS BoG election and in the Division X director's election. The CSS BoG is responsible for all of the important decisions affecting the CSS, such as approving conference budgets, authorizing funds for special Society initiatives, approving officers and editors, and so on. The Division X

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an important element of system design, except that control fundamentals become secondary. I believe a course that uses a simple plant such as a dc motor is still the most effective introduction to the concepts of modeling, stability margin analysis, robustness, and disturbance rejection. However, to keep a student's interest piqued, one could creatively augment the course content with the latest trends, such as haptics, virtual reality, gaming, and robotics.

CSM: *What do you do when you're not developing new lab experiments, visiting clients with new ideas, or tending to the Quanser booth at conferences?*

Jacob: I have a young daughter and a growing family, so that keeps me pretty busy. I try to find time to mountain bike and snowboard. Unfortunately, my ambition exceeds my ability, and occasionally I hurt myself. The worst accident was when I broke both wrists a couple of summers ago while attempting to take a jump on my mountain bike. Clearly, I did not understand the dynamics involved in landing the bike properly, and even if I did, I doubt I had the control authority!

New *CSM* Corresponding Editor

CSM seeks to publish reports on conferences and workshops as well as all significant control-related events. The new *CSM* corresponding editor for conferences is Zongli Lin. Conference organizers are encouraged to contact Prof. Lin (zl5y@virginia.edu)to arrange advance publicity and to plan for the submission of conference reports.

Prof. Lin received his B.S. degree in mathematics and computer science from Xiamen University, Xiamen, China, in 1983, his master of engineering degree in automatic control from the Chinese Academy of Space Technology, Beijing, in 1989, and his Ph.D. degree in electrical and computer engineering from Washington State University, Pullman, in 1994. He is currently a professor with the Charles L. Brown Department of Electrical and Computer Engineering at the University of Virginia. Previously, he worked as a control engineer at the Chinese Academy of Space Technology and as an assistant professor with the Department of Applied Mathematics and Statistics at the State University of New York at Stony Brook.

Zongli Lin of the University of Virginia. Prof. Lin is the new IEEE CSM corresponding editor for conferences.

His current research interests include nonlinear control, robust control, and modeling and control of magnetic bearing systems. He has published 250 papers, over 90 of which are in archival journals. He is also the author of *Low Gain Feedback* (Springer-Verlag, 1998), a coauthor (with Tingshu Hu) of *Control Systems with Actuator Saturation: Analysis and Design* (Birkhauser, 2001), and a coauthor (with B.M. Chen and Y. Shamash) of the recently published *Linear Systems Theory: A Structural Decomposition Approach* (Birkhauser, 2004). For his work on control systems with actuator saturation, he received a U.S. Office of Naval Research Young Investigator Award in 1999.

Prof. Lin was an associate editor of *IEEE Transactions on Automatic Control* from 2001–2003 and has been an associate editor of *Automatica* since 2004. He is a member of the IEEE Control Systems Society's Technical Committee on Nonlinear Systems and Control and heads its Working Group on Control with Constraints.

President's Message

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director represents several Societies, including the CSS, on TAB. Of the roughly 8,000 current CSS members, less than 1,000 routinely vote in these elections. I would like to see a higher level of participation from you, our membership, since your vote is extremely important for selecting the kind of top-quality people we need to represent us at both the Society and the IEEE levels. So please remember to cast your vote when you receive the e-mail notifications from IEEE.

As always, I look forward to receiving your feedback at mspong@ uiuc.edu.

Mark W. Spong
President
IEEE Control Systems Society