What Training is Needed by Practicing Engineers Who Create Cyberphysical Systems?

Christopher Scaffidi
School of Electrical Engineering and Computer Science, Center for Applied Systems and Software
Oregon State University
Corvallis, OR, United States
cscaffid@eecs.oregonstate.edu

Abstract—The creation of cyberphysical systems requires not only the effective education of future engineers in the classroom, but also ongoing training to support life-long learning by practicing engineers, who will continuously face new technologies and challenges. But what topics exactly should this training cover? To answer this question, an analysis was conducted of an online forum used by programmers who create cyberphysical systems with the LabVIEW development environment.

This examination of over 150,000 forum message threads has highlighted crucial gaps in the training of practicing engineers, especially in the areas of hardware-software integration, as well as the design and implementation of user interfaces and algorithms. A complementary review of the available online training materials relevant to these topics reveals the need for more systematic support for learning by practicing system engineers. These results provide empirical support for ongoing efforts to provide more effective education of current and future engineers of cyberphysical systems, including through reuse of third-party code and other resources to support learning.

Keywords—training; online education; cyberphysical engineering

I. INTRODUCTION

The steady increase of cyberphysical systems in daily lives is driven by many factors. Researchers have noted that relative to purely physical systems, software-controlled systems can save space [10], reduce costs while increasing maintainability and/or reusability [13], and enhance functional benefits such as “comfort, health, services, safety and security” [14].

To meet the rising demand for cyberphysical systems, universities, governments and corporate partners have invested in new projects aimed at training software engineering students to participate in this growing field [14]. Efforts like these have yielded, for example, new laboratory facilities where students can develop technical skills [1] and new resources for coaching students through the process of creating systems [7][8].

Practicing engineers are an important target audience for these efforts (in addition to the “university-age” population of students who have not yet graduated). Technology moves fast, bringing with it a continuous demand for training and retraining in cutting-edge tools and technologies throughout life. A review of European initiatives since 2004 mentions summer schools, distance-learning programs, Master’s degrees, and many other efforts aimed at the professional audience [14]. In the United States, the National Science Foundation has funded similar efforts since at least 2008 [11].

Recognizing then the imperative for continuing education, both inside and outside the university setting, it remains a question of what this education should cover. Researchers and educators have proposed many different empirically-driven suggestions for topics, with dependability and efficiency frequently mentioned.

But sometimes it comes as a surprise that professional engineers need help in a certain area. For example, one study observed professionals who created a system for use by disabled and elderly users, and this research discovered that the engineers needed better training in the design and implementation of accessible cyberphysical systems [5]. This insight about engineers’ actual training needs was only obtained by paying attention to their everyday work.

To uncover additional training needs of practicing engineers who create cyberphysical systems, this paper presents an analysis of over 150,000 questions that had been posted to an online website forum, whereby engineers asked for help with their everyday work. The forum has been operated since 1999 by National Instruments, which is the company that provides the LabVIEW development environment. With this programming tool suite, engineers draw visual code that they can then compile and deploy to a broad range of devices and computers. For example, LabVIEW programs (called “Virtual Instruments” or “VIs”) can run on FPGAs, microcontrollers, traditional personal computers, web servers, and the cloud. VIs can implement a broad range of functionality that includes, for instance, reading from sensors, analyzing signals, processing video, communicating via the internet, reading and writing databases, and controlling hardware via digital or analog outputs. LabVIEW’s broad range of cyberphysical functionality makes the corresponding forum a wealth of information about the actual training needs of practicing engineers. In addition to data from the forums, which focused on questions that engineers have, the study also investigated the online training materials that already exist to address these engineers’ gaps in knowledge. This latter investigation revealed opportunities for future efforts aimed at helping practicing engineers to learn in the field, without the need to return to university.

This work was sponsored by National Instruments.