

Toward 21st Century Cyber-Physical Systems Education
National Academies of Sciences, Medicine, and Engineering
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The National Academies of Sciences, Medicine, and Engineering's Computer Science and Telecommunications Board is conducting a study for NSF to examine CPS workforce requirements and the content and form of CPS education, especially at the undergraduate level. Its Committee on 21st Century Cyber-Physical Systems Education has convened two workshops and received additional expert briefings, material that is summarized in an interim report released in Spring 2015. The interim report also outlines major themes that will be elaborated on in the study's final report:

- **CPS skills and experience are in demand.** Anecdotal reports from industry representatives point to two areas of demand: (1) as CPS becomes an increasingly important aspect of products and services, some companies are looking specifically for people with an educational concentration in CPS—which some dubbed the “CPS engineer” and (2) CPS skills are becoming increasingly important across a wide range of engineering specialties.
- **A lack of familiarity with the term “cyber physical systems” itself may impede student interest in the field.** Although cyber physical systems have been widely used and designed for some time now, perspective students may not perceive CPS as an attractive area of study and work in part because they do not recognize the label. By contrast, students are often eager to enroll in courses with “robotics” or “internet of things” in their title. Both of these overlap with CPS, although they may not cover all of the foundations needed for CPS.
- **“CPS engineering”¹ may be emerging as a distinct field of engineering.** CPS draws knowledge and approaches from multiple areas of engineering, and may indeed have significant overlap with other areas of engineering; however CPS has begun to take on a distinctive character.
- **There is growing agreement on the core elements of CPS but a diverse set of approaches to fashioning CPS programs is likely and appropriate.** It seems possible to outline a set of core concepts, principles, and themes, and the committee will be endeavoring to use them to lay out a model undergraduate curriculum in CPS for its final report.
- **The need for CPS skills is becoming pervasive across engineering and computer science.** CPS are deployed in a variety of domains including civil, mechanical, and aerospace. CPS engineers will not replace the need for engineering that focuses on deeply understanding of topics specific to these fields, but people with such skills will increasingly be central to engineering teams.

¹ The term CPS engineering or CPS engineer is used here to mean a set of skills and knowledge needed to design and build a CPS and a person with those skills; the term is not limited to a set of credentials or someone who has a degree or certification in CPS.

- **It will likely not be sufficient to simply bundle existing courses to create a CPS program.** Although many of the topics in CPS can also be found in current engineering and computer science courses, the emphasis on the interaction of the cyber and physical is unique to CPS.
- **CPS education programs need to include a hands-on component.** These opportunities can be provided to students via an interdisciplinary capstone course, extensive course-specific labs, an engineering elective course focused on a single project, or internships and industry-academic partnerships.
- **Other paths to CPS knowledge will be important.** Although this study will focus on 4-year undergraduate curricula, other paths for students and the work force to gain CPS knowledge are also important. T

The interim report also identifies several challenges in creating and supporting cyber physical systems programs at universities that will be explored further in the final report:

- **Working across disciplinary and department boundaries can create significant challenges.** CPS exists at the intersection of multiple disciplines. This has significant impact on how a curriculum will be developed and taught.
- **A significant challenge will be identifying, recruiting, and educating appropriate faculty members to teach new and different courses.** Many universities currently have a limited handful of faculty that can teach CPS courses. If schools are to develop and offer a full CPS curriculum, additional faculty members will be needed.
- **Textbooks, curricular materials, and laboratory facilities will need to be developed.** Developing these critical resources requires both time and financial support.

The final report from the study will be issued in early 2016.