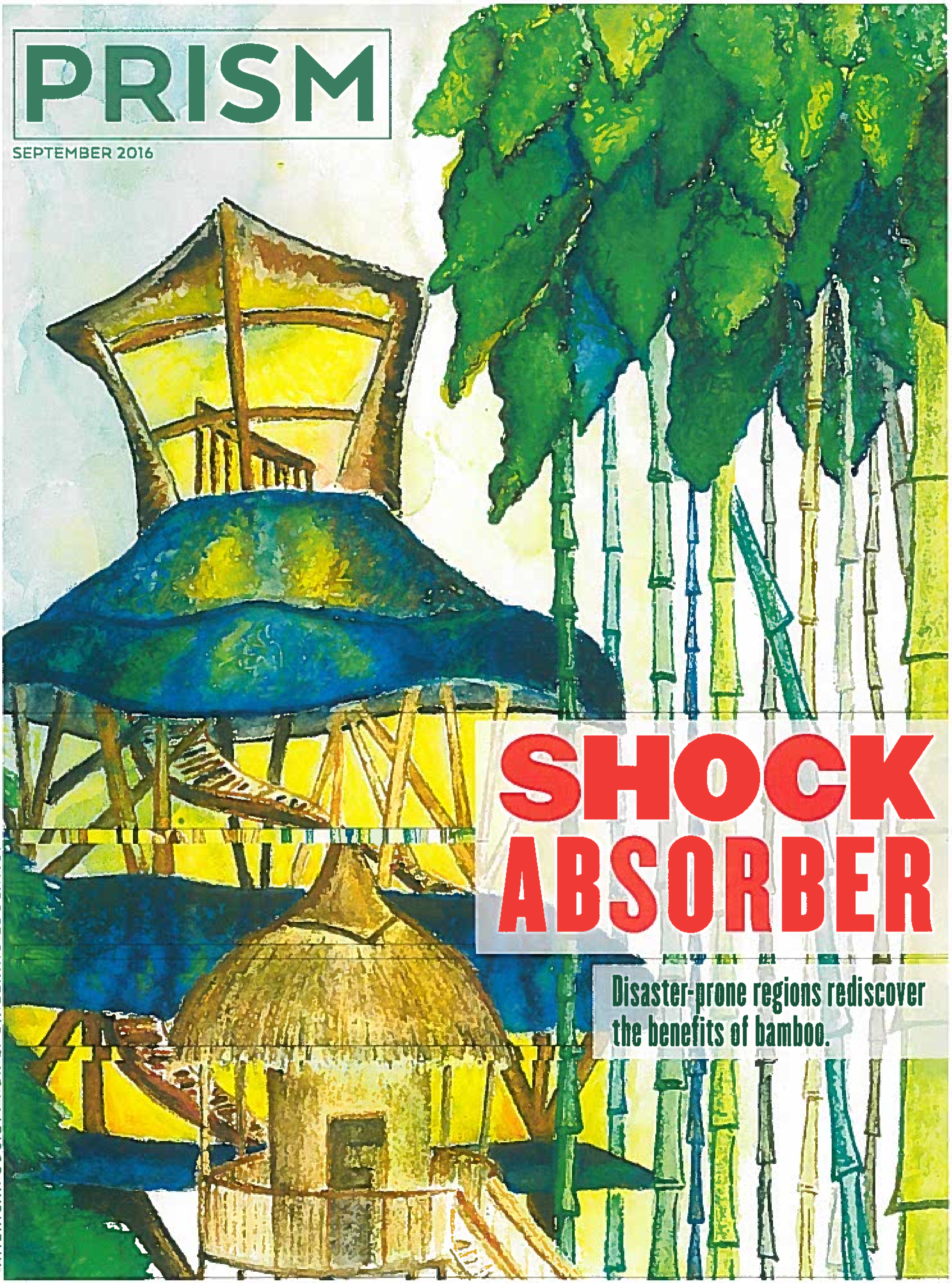
PRISM

SEPTEMBER 2016



SHOCK ABSORBER

Disaster-prone regions rediscover the benefits of bamboo.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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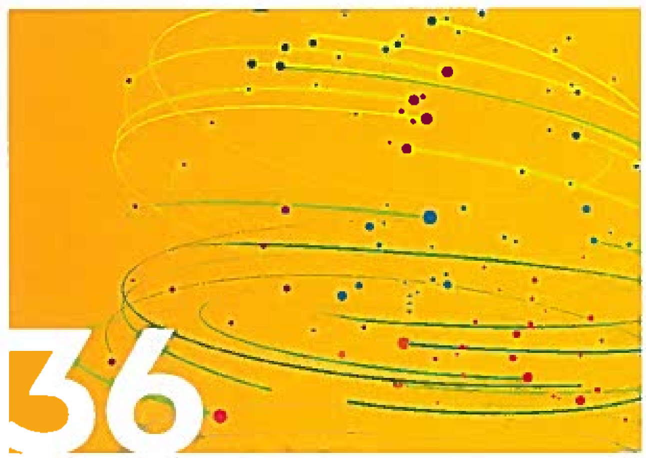
FEATURES



COVER IMAGE

Jennifer Pocock captures both simple and extravagant bamboo construction, taking inspiration from Elora Hardy's Sharma Springs house in Bali and traditional stilted structures.

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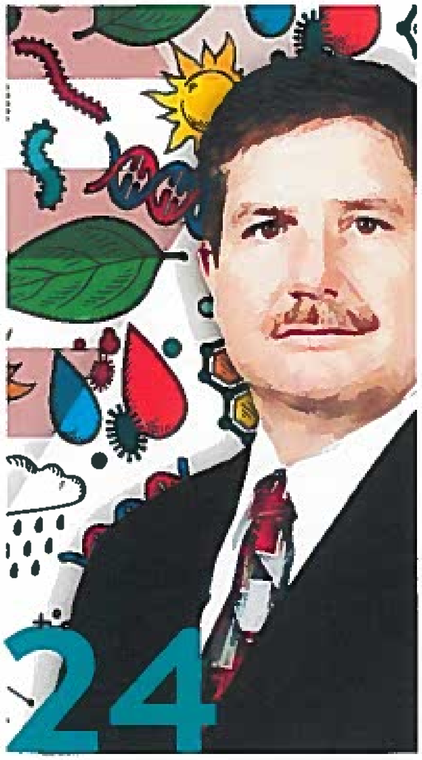

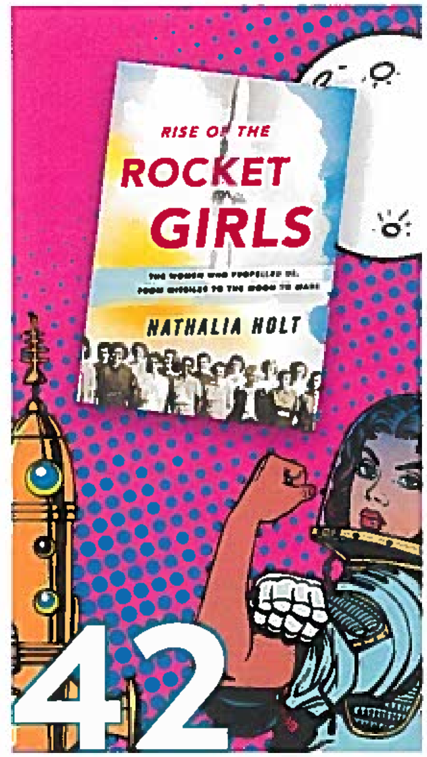

COMMON DENOMINATORS OF LEARNING

Whether preparing for industry or research, students need to be engaged. Four strategies are key.

Engineering companies worldwide seek graduates who can hit the ground running. They want universities to train students, from the first year onward, for engineering practice. Faculty members at research universities, however, are at least as interested in producing engineering scientists as they are in graduating new professionals. Are these goals incompatible? They don't have to be.

Research around these competing objectives reveals some common ground. Whether their future lies in industry or the lab, students learn best when pedagogy is aligned with four metacognitive strategies: *rehearsal, elaboration, organization/application, and representation.* Together, they can be summed up in two words: student engagement. Once instructors understand their importance, these strategies can be applied in a variety of ways in both traditional and flipped classroom formats. Proven practices range from demonstrations that infuse concepts and principles, to small learning communities in which students co- or peer instruct, to case-based or problem-based longitudinal group assignments.

> ***PROVEN PRACTICES** RANGE FROM **DEMONSTRATIONS** THAT INFUSE **CONCEPTS** AND **PRINCIPLES** TO SMALL **LEARNING COMMUNITIES** AND **PROBLEM-BASED GROUP** ASSIGNMENTS.*

Foundational introductory engineering courses should incorporate demonstrations and worked examples specific to applications of key concepts and engineering principles. Students should experience a principle or concept in action, so that they can apply it later in problem representation in advanced, problem-focused courses.

Instructors should select three to five essential concepts and principles to demonstrate, rather than covering a larger number superficially. Mini-investigations provide practice using concepts and principles: Students learn to and practice classifying subject matter, and how to ask scientifically fruitful questions. Concept inventories and concept maps should be used to assess and connect concept mastery within and across courses. These demonstrations eliminate instructional monotony by allowing students to visualize or experience concepts and principles in action.

Students in midlevel (sophomore and junior) engineering courses should engage in forward-planned, design thinking practice to prepare them for senior design and capstone courses. Some of these practices can be organized to support global problem solving, which could include a study-abroad component.

Mid- to advanced-level courses with labs require that students apply through experimentation the principles and concepts learned in foundation courses. Most important, students must distinguish between data and evidence, identify problems and formulate solutions, and make predictions and observations to provide scientific explanations. Students in senior engineering courses should experience device design and problem solving centered on cross- and interdisciplinary design and capstone experiences, simulating what they are likely to experience in either industry or graduate research.

Each of the practices based on the four learning strategies can be replicated and scaled in both teaching and research university engineering programs. The challenge is persuading faculty members to accept the importance of the strategies and to apply them. This may be particularly hard to accomplish at universities where training in best practices must compete with research for a faculty member's attention.

Many schools have helped improve student learning by supplying technology to invert classrooms, but this is only one path to improved learning. At the University of Southern California's Viterbi School of Engineering, we adopted a phased approach that built on the enthusiasm of early faculty volunteers to draw in their colleagues. The effort was part of a broad initiative launched in the fall of 2013 to engage students more fully in classroom learning and beyond.

Early adopters, both tenure-stream and full-time teaching faculty, were motivated by a desire to improve students' learning experiences and were willing participants in small group communities-of-practice and discussions. Broader participation was encouraged by both department chairs and the Engineering Dean's office. The school offered mini-workshops, small group department level demonstrations, guest speakers at engineering education retreats, viewing of demos in action, faculty-to-faculty mentorship, and panel-based events to share best practices. Innovators contributed their practices to a bank from which other faculty members could draw.

Enthusiasm has indeed spread. Currently, 103 faculty members have implemented engaging practices in class, and in any given semester, between 80 and 150 courses are infused with the four learning strategies. Student achievement and satisfaction have improved, and faculty members report greater satisfaction with their teaching. The result, we hope, will be both better- skilled professionals and inspired researchers.

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