Professors Lizabeth Schlemer and Linda Vanasupa and consultant Roger Burton offer an overview of their research into networked learning communities as a basis for advancing STEM education.

**Could you provide some insight into your research backgrounds?**

Together, the three of us have researched the education of engineers and the practice of engineering – broadly defined. Burton spent 20 years as a consultant for multinational corporations and government agencies, working on the large-scale implementation of sustainable business practices. Schlemer’s career has spanned both industrial practice and higher education, looking into how engineering education systems can make room for our ‘whole’ selves. Vanasupa’s work began with microelectronics and transitioned to research on how to enable sustainable design.

**Why are you interested in developing STEM education?**

We started asking questions about transformational change based on our conviction that the current system of higher education in the US is not preparing upcoming generations for the world that they will inherit. This is a product of the paradigms of the globe as a simple system, where problems are small and solvable. In reality, the world occurs to us as a complex system in which challenges cross disciplines in an interconnected way. Therefore, if one desires the ability to successfully live and work in such a system, they need to learn in ways that account for complexity.

**How do you define the term ‘networked learning community’?**

A networked learning community is, in a sense, a way of mirroring how biological ecosystems function – the source of nutrients is outside the organism itself. Nutrients are acquired through a network of symbiotic relationships with other organisms; they are collaborating for their coexistence. In terms of STEM education, we view our organisations as organisms. The network serves to exchange informational nutrients with and across the higher education ecosystem. At a distant node, a different perspective is possible. We learn from one another across the network in a way that isn’t possible when researchers coexist in a single-organisation ecosystem.

**What role do you think such communities can play in improving teaching and learning of college-level STEM content?**

When we use the term ‘community’, we mean a networked reality of people with shared qualities. These traits are generated collectively and sustained through individual and collective participation.

One of the most important aspects of such a community structure is the way in which it allows us to come into contact with fundamental assumptions. We are typically unaware of them as models, but operate with them in the background because we tacitly hold them as self-evident truth. A community based on shared properties of learning, love, compassion and a liberating impulse serves as a reflective surface through which we can become aware of such models when sufficient diversity is present.

The community as such is the basis for learning as an emergent collaborative phenomenon, rather than a prescriptive one. The real discipline and practice around the generation and maintenance of community translates into a learning environment in which addressing very challenging content can be created and sustained without the use of force. In essence, this is the basis for critical thinking as a collective way of being, rather than a technical process.

**You are focusing on STEM education in several traditionally Hispanic-serving institutions. How would you like to see STEM education improve?**

All higher education seems to be subject to the same consequences created by the traditional model of learning. In STEM culture in the US, negative consequences are often amplified because of the unconscious adoption of values and metaphors of the industrial-military origins of the profession. We would like to see the STEM education enterprise become conscious of the embedded value system within curricula. Currently, these invisible value systems are largely responsible for many of the problematic phenomena that national efforts are attempting to solve.

For example, STEM higher education, and engineering education in particular, has made little progress in the last 30 years in substantively balancing the graduate demographics in proportion to the percentage of women and underrepresented ethnic groups. We continue to attempt to solve this problem at the level of students, when the problem is systemic. The very activities that conserve engineering education in the way a factory might perfect an assembly line are the very same that create inhospitable cultures and learning environments for students like women and Latinos/Latinas, who may hold alternative value systems. These exclusionary learning cultures are created and maintained by all actors within the system by unconsciously-held paradigms that prioritise profit and technology over human considerations.
A team at California Polytechnic State University is exploring groundbreaking approaches that could transform STEM education, while better preparing the next generation of engineers and scientists.

SINCE THE INDUSTRIAL REVOLUTION, scientific research has mostly followed the reductionist approach, whereby a particular problem is broken down into smaller, manageable chunks and investigated, with a view to applying the findings to similar, simple systems in which one can control the variables.

To a large extent, higher education in the US has followed suit. Many still regard the teaching and learning process as something that, once perfected, can be applied in a one-size-fits-all way to achieve optimal results from each cohort of students. While true in some cases, this style of education brings with it a number of unintended consequences, such as a tendency to work in silos. Professors Lizabeth Schlemer and Linda Vanasupa of California Polytechnic State University with consultant Roger Burton also see this style of education as directly linked to the lack of diversity within science and technology.

While the participation of women and certain ethnic minorities – demographic groups that have been traditionally underrepresented – in STEM has increased in most sectors in recent years, 2013 National Science Foundation statistics show that progress remains more sluggish than many would have hoped, particularly within engineering and the physical sciences. Many efforts to try and address this imbalance have focused solely on student recruitment, while introspective changes at the systemic level have been few and far between.

SHAKING UP HIGHER EDUCATION

Schlemer, Vanasupa and Burton have been exploring alternatives that could potentially transform the STEM teaching and learning experience and make it a more inclusive space for all students. Sharing the belief that the current higher education system does not adequately prepare students for the sustainability-related challenges that they are likely to encounter in their future careers, the researchers have come together in order to work towards a solution.

A core tenet of their approach is a shift from what they view as a factory-style teaching system to a more community-based one that incorporates the interests, histories and abilities of both teachers and students. The team firmly believes that the quality of interpersonal relationships is vital to the learning experience, which includes educators and students alike.

COLLABORATIVE LEARNING AS A NETWORK

The team has been investigating the efficacy of a teaching style that aims to break down the rigid barriers imposed by traditional
eductional methods, encouraging creativity and compassion amongst learners. Their work revolves around the concept of a ‘networked learning community’, an environment which they believe will foster collaborative learning. The purpose of this network is to bring together learners, educators and other stakeholders – such as community partners – in a collaborative process of exploring new ways of creating the social value of a thriving community.

This networked learning community flips the traditional idea of a hierarchical learning system on its head. Instead of an emphasis being placed upon students to learn from a sole ‘authorised expert’ teacher, each individual within the community is empowered to make contributions to learning and teaching, making the approach much more egalitarian. In this system, all hold responsibility for individual and community learning.

The researchers are keen to point out that their community is not simply a variation on the professional society model, which they argue is subject to similar consequences as the higher education system that they are looking to rethink. “Existing societies are born out of the same paradigms of dominance and competition; therefore, they function less like collaborative networks and more like opportunities to gain some competitive advantage for scarce resources,” Vanasupa explains.

**SUSTAIN-SLO: A LIVING LABORATORY**

In order to test and fine-tune their theories about the networked learning model, the group set up the Sino-US Strategic Alliance for Innovation, San Luis Obispo (SUSTAIN-SLO), an initiative for California Polytechnic State University first-year students. Through SUSTAIN-SLO, the researchers aim to establish how educators can be supported in the transition to teaching in a collaborative model, given that competition is deeply embedded into the framework of human thought.

The programme brings together students with 10 faculty members from a range of disciplines and community partners from a variety of organisations in San Luis Obispo, California. By the end of the six-month experience, each student will – with the support of peers and faculty members – have progressed toward their individual degrees and worked with their community partner on a project that promotes sustainability and creates value. Since its inception three years ago, 45-65 students from over 20 different disciplinary majors have annually participated in SUSTAIN-SLO. Next year, the University has offered SUSTAIN-SLO a dormitory for the 100 expected freshmen participants, so that the SUSTAIN experience can be a true living laboratory.

**THE CHALLENGES OF CHANGE**

Creating meaningful alternatives and change in US universities will be no mean feat, given that these institutions have built policies and work in ways that conserve traditions, resulting in a uniformity among faculty and students. Aware of the enormity of such a task, Schlemer, Vanasupa and Burton have been investigating ways in which this can be successfully achieved in their research.

They favour action research because it recognises the unique situation in which the research is happening. Action research is a reflective method that includes the investigator as a subject of the study, and is appropriate for complex systems. Rather than aiming to establish cause and effect, action research involves sensitivity to weak signals within a given system so that the researcher can adjust towards achieving the desired result. Action research is practised within SUSTAIN-SLO, and has shown promise as a viable way of creating meaningful, self-initiated change.

**KEY FINDINGS**

Through its study, the team has identified two patterns of change-related behaviour of interest. One, the ‘strange attractor’, refers to a phenomenon by which a given system moves towards a particular state without obvious direct action. The researchers describe this state as one of compassionate attention that is characteristic of nurturing. The other pattern is one of ‘strong emergence’ of a non-predictable state within the system. “What we have found is that when certain conditions are met in the learning system, there is a spontaneous, unpredictable emergence of existential crisis within faculty and students alike,” Vanasupa describes. “Because of the presence of the strange attractor, individuals are able to successfully navigate the existential crisis. We often use the term ‘transformational learning’ because we are finding that the learning results in a re-constitution of peoples’ own identity. This is consistent with understanding education as a fundamentally emancipatory process.”

Recognising the human learning system as a complex system, they draw from complexity theory to identify the factors in transformational learning. These include the presence of the strange attractor, a diversity of perspectives, a global constraint, or boundary, felt by the community, a sense of commitment to overarching aims and the opportunity for individuals to self-organise within the learning system to achieve these aims.

**CROSSING DISCIPLINES FOR CHANGE**

As they consider the ways that STEM education in the US can evolve, the team is clear that any changes effected without considering the mental models that created the status quo are likely to amplify the problems. “In order to change the current dynamics around STEM learning, we must collaborate in human systems that extend beyond disciplinary boundaries,” Vanasupa concludes.

**INTELLIGENCE**

**OVERCOMING THE BARRIERS TO INDIVIDUALIZED TEACHING AND LEARNING**

**OBJECTIVES**

The research focuses on the change process for faculty members to teach in a collaborative model within institutions that are optimised for competition.

**KEY COLLABORATORS**

Co-Principal Investigators: Lizabath Schlemer; Linda Vanasupa, California Polytechnic State University (Cal Poly), and Roger Burton, Society for Organizational Learning-China.

Collaborating faculty members at Cal Poly: Courtney Brogno, English • Robert Echols, Physics • Matt Ritter, Biology • Craig Russell, Music • Leslie St John, English • Nina Truch, Communication Studies • Jane Lehr, Ethnic Studies • Pete Schwartz, Physics • Erma Stauffer, Communication Studies • Neal MacDougall, Agribusiness • Tom Trice, History • Roberta Herter, Education

Collaborators external to Cal Poly: Ginger Hendricks, Research Consultant • Sarah Ramirez, BeHealthyTulare, USA • Alice Pawley, Robin Adams, Purdue University, USA • Emily Allen, Cal State-Los Angeles, USA • Susan A Ambrose, Northeastern University, USA • Helen L Chen, Stanford University, USA • Alicia Dowd, University of Southern California, USA • Crystal Lo Vetere, Centris College, USA • Jinny Rhee, San Jose State University, USA • Ruth Rominger, Garfield Foundation, USA • Liz Rozell, Bakersfield College, USA • Jonathan D Stolk, Olin College of Engineering, USA

**FUNDING**

National Science Foundation – award nos. 1025264, 1044430, 1256226

**CONTACT**

Lizabath Schlemer
Professor, Industrial and Manufacturing Engineering
California Polytechnic State University
San Luis Obispo, California 93407, USA
T +1 805 756 2183
E lschleme@calpoly.edu

LIZABETH SCHLEMER has been an instructor at Cal Poly since 1993. She holds a BSc and MSc in Industrial Engineering, and an MBA and a PhD in Educational Research. She also has 10 years of work experience where she held positions of increasing responsibility. Most of her current research activities centre around engineering education and enhancing engagement.

ROGER BURTON has been working for the past 20 years as a systems change consultant and change catalyst with many of the world’s largest corporations and organisations. His work has included the executive suite and the shop floor across a wide variety of industries and endeavours.

LINDA VANASUPA is a professor of materials engineering at the California Polytechnic State University. She also serves as co-director of the Center for Sustainability in Engineering at Cal Poly. Her life’s work is focused on creating ways of learning, living and being that are alternatives to the industrial era solutions.