TIAA Institute

Bridging Learning Research and Teaching Practice:
The Learning Engineer

The TIAA Institute invited work by Candace Thille, director of learning science at Amazon and associate professor in the Graduate School of Education and affiliate faculty in the Neurosciences Interdepartmental Program at Stanford, to help higher education leaders understand the basic science of human learning and how it can most fairly be put into practice.

Colleges and universities are under intense pressure to increase access, reduce cost, educate a more diverse student body, and close achievement gaps between rich and poor. Higher education's dual missions of research and teaching ideally position the sector to address these challenges by discovering and enacting the most effective processes for teaching and learning.

Resource constraints and many traditional higher education structures contribute to a persistent gap between learning research and teaching practice.

The science of learning

The science of learning is an interdisciplinary field comprising cognitive science, neuroscience, education, psychology, anthropology, sociology, economics, and computer science. Much of the research uses external behavioral measures to assess learning. Neuroscience, on the other hand, reveals that learning can be observed through changes in the brain. And foremost among advances in computer science is machine learning—the study and construction of algorithms that can learn from and make predictions on data.

A branch of machine learning, reinforcement learning, is a framework that shifts the focus of machine learning from simple pattern recognition to experience-driven sequential decision making by machines. Finally, "deep learning" belongs to a class of dynamic models that connect artificial neurons over time. These adaptive neural networks already have contributed to rapid advances in realms outside education, such as speech recognition and image captioning.

Much of the excitement in using technology to transform education is the promise that adaptive systems, with limited human intervention, can personalize instruction for large numbers of students. Data collected from a student's interactions in an adaptive system are modeled, and predictions generated by the models are used for pedagogical decision making. The system can either make autonomous decisions (e.g., decide what learning task to give the student next) or give information to the instructor to support their decision making (e.g., learning dashboards that present a visual representation of a student's predicted competence on specified learning outcomes).

Students most in need of robust personalized academic support systems often are enrolled at institutions with the most resource constraints.

Opportunity and risk

Educational data mining (EDM), knowledge modeling, and the teaching and learning decision-support systems that can be built from them hold tremendous potential to improve instruction and student learning outcomes.

But the systems and algorithms used to model the data are not neutral. Any system built using data will reflect the biases and decisions made when collecting that data, as well as the behaviors and judgements of the groups and individuals from whom the data are collected. There are multiple examples from other sectors showing the negative impact of systems built on biased or unrepresentative data.

Higher education can use research in human learning, data mining, data modeling, and the design of reporting systems to detect and counterbalance unconscious implicit biases. For example, mining of large data sets in one study already has revealed that significant gendered performance differences are ubiquitous in large introductory STEM lecture courses. This has led to hypotheses that evaluation methods used in STEM lecture courses interact with stereotype threat to create those differences.

If models are not transparent and critically evaluated before they are built into predictions systems, data mining and the resulting decision-support systems will inherit the prejudice of prior decision makers, reproduce existing patterns, and further entrench biases in the education system.

Stereotype threat

Many studies have demonstrated how environmental and social cues in the learning context can either facilitate or threaten one's sense of belonging and social identity. Stereotype threat, for example, contributes to systematic underperformance in a variety of contexts. Negative consequences include not just hindering learning, but also reducing self-regulatory abilities, depressing motivation, and redirecting career paths, among others. Stereotype threat effects have been shown on groups and tasks as diverse as African American students, first-generation college students, women in historically male-dominated engineering programs, white athletes, gay men in childcare, and women in driving

The learning engineer

Today's challenges call for creation of a new academic role: the learning engineer. Their role will be to bridge the gap between learning research and teaching practice, and assure that research is use-inspired and informed by practice. Through this bi-directional collaborative role, the learning engineer will be the catalyst for much-needed change in the interplay of learning research and teaching practice in higher education.

Further, learning engineers won't simply assist in designing more effective classroom practices, but also will help build the educational technology and back-end data systems that support instructional practice, student learning, and learning research. Currently, adaptive educational systems are being designed and built mostly outside of the academy and sold into the academy as tools and products to facilitate innovation in teaching and learning.

Learning engineers' work will encompass numerous areas of research in the science and engineering of learning, including:

- how to design the technology to support teaching and learning
- which data to collect
- the factors to include in a predictive model and how to weight them
- which modeling approaches and algorithms to use
- how new patterns revealed in the data should be interpreted and used
- the ideal division of tasks between humans and machines
- the boundaries for when to use predictions for autonomous decision making or for supporting human decision making
- what information to represent and how to represent it in support of human decision making

In an academic context, all of these research areas must be transparent and subject to peer review and challenge—or the process is better described as alchemy, not science. Learning engineers can help ensure that learning isn't compromised by opaque models and systems that serve to perpetuate existing patterns and prejudice.

Without transparency and peer review, the design of educational technologies and the modeling and interpretation of data for pedagogical decision making are alchemy, not science.

Final word

The future is clear: technology will be a core part of the teaching, learning and research processes of higher education. Yet a basic tenet of any successful business strategy is that its core business processes should not be outsourced. If research and teaching institutions continue to outsource educational technology design, data collection, and data modeling, they not only run the risk of violating that basic tenet, but also jeopardize the opportunity to transform higher education to support *all* students.

It is critically important that higher education leaders, policymakers, social scientists, learning scientists, and learning engineers balance the imperative to innovate with mechanisms to ensure that the economic and social benefits of that innovation are broadly shared across society and contribute to fulfilling the multifaceted mission of higher education.

Read more:

Thille, Candace M. (2016). *Bridging Learning Research and Teaching Practice for the Public Good: The Learning Engineer.* New York, NY: TIAA Institute.

Please note that the underlined text throughout this piece is hyperlinked in its online version so that you can readily access the resources cited herein.

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