Using complex systems approach to study educational policy

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Educational policy is controversial: positions on achievement gaps, troubled schools and class size are emotionally charged, and research studies often come to very different conclusions.

But what if there was a new way of looking at the problem -- a way that treats education as a complex system (taking into account all interactions) and uses computer modeling and network analysis to provide a comprehensive look at the outcomes of policy choices?

Researchers at Northwestern University's McCormick School of Engineering and Applied Science and School of Education and Social Policy argue in an article published Oct. 1 in the journal *Science* that such an approach can help integrate insights and better inform educational policy. By breaking down policies into simple rules and computationally modeling them under different conditions, professors Uri Wilensky and Luis Amaral have found a promising new way to understand policy issues such as school choice and student tracking.

Wilensky, professor of learning sciences and electrical engineering and computer science, and Amaral, professor of chemical and biological engineering, authored the paper with several of their current and former graduate students and colleagues. The article grew out of a three-year, National Science Foundation-supported project they conducted.

In the article, Wilensky and Amaral argue that current educational policy research often falls into two categories: effects-based, which focuses on

quantifying "what works" in education, and mechanism-based research, such as ethnographies, case studies and laboratory experiments that focus on individuals and "how it works."

But to get a complete view of education, researchers must use methods that integrate insights about micro-level processes (the student) with macro-level outcomes (student achievement). To do this, Wilensky and Amaral look at education as a complex system: a system with many interacting parts that only can be understood by examining the interactions of the parts and the networks that connect them. Knowledge of the parts alone doesn't lead to understanding of the whole system.

"Considering all the published research, it is hard to draw conclusions on educational policies," Wilensky said. "In this modeled world you can simulate all kinds of alternative policies and conditions and then better understand their implications."

Engineers and scientists conducting research on complex systems use what is called agent-based modeling to simulate, explore and predict such systems. Recently, social scientists have been developing and computationally simulating educational policy scenarios. This allows them to see how individual and group-level behaviors relate to system-wide outcomes.

In the article, the authors cite several other studies and their own research as evidence that this approach works. Wilensky and Amaral, along with Louis Gomez, formerly with Northwestern and now professor of learning sciences and policy at the University of Pittsburgh, and Spiro Maroulis, Wilensky's former graduate student and now a visiting professor and postdoctoral fellow at Northwestern's Kellogg School of Management, have used a modeling approach for a hot educational issue: school choice.

They use Wilensky's NetLogo agent-based modeling software along with student and school-level data from Chicago Public Schools to better understand the sensitivity of district-level outcomes, such as mean achievement to differences in the ways students choose schools. In one modeling scenario, they allowed for schools with a greater ability to increase student test scores to enter the district and found that when students valued a school's test scores much more than its geographic proximity, it could constrain improvement in the district. That is because it made it more difficult for new schools to survive.

"The schools that initially look very good get swamped, and they get overwhelmed and tend to close," Wilensky said. Such research could pave the way for new school-choice programs.

In another study, Wilensky, Amaral and their students used surveys to look at friendship networks among high school students. "We were able to use algorithms developed by Amaral to separate out sub-communities -- the friendship groups -- and figure out who were the key pivotal players and how they affected the group," Wilensky said.

The researchers examined groups comprised of both high achievers and low achievers. They found that in a group that contained mostly high achievers, the low achievers tended to improve. In a group that contained mostly low achievers, the high achievers tended to do worse. Moreover, students in the high-achieving friendship groups improved their scores more than students in the low-achieving groups.

"Ultimately, a complex systems-based approach provides a new way of looking at educational and social policies and should be incorporated into graduate training programs," Wilensky said.

"It's a new form of argument that will help resolve disagreements," he said. "By breaking down a complex system and figuring out the rules that

generate it, we can grow the system in the computer and create models that can guide us towards leverage points that will help us determine which policies will work."

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