A formula for predicting innovation

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Credit: Charles Rondeau/public domain

By the time she was six years old, Nadya Bliss had already figured out her professional calling. She knew that one day she would be a mathematician.

"I'm a geek at heart," confesses Bliss, now the assistant vice president for research strategy in Arizona State University's Office of Knowledge

Enterprise Development. "But I've never wanted to be the kind of mathematician who just sits in the corner and does things on her own."

Bliss knew that crunching numbers could have a broad impact beyond just the "geek" community. As a result, she seeks out interdisciplinary research opportunities that let her contribute to a wide variety of fields.

She is currently working with science historian Manfred Laubichler, a professor in ASU's School of Life Sciences, part of the College of Liberal Arts and Sciences. The two researchers have developed a set of mathematical techniques to detect the emergence of innovation in research. It's a broad framework that pulls together concepts from graph theory, electrical engineering and applied mathematics to identify interesting patterns from large networks.

"Analysis of networks is basically analysis of entities and relationships among them—for example, people and their friends and how they're interconnected," Bliss says. Other examples of networks could be cars on a road, the interaction of proteins or computer networks. Bliss and Laubichler are focused on a network of research citations from about 300,000 authors in the field of developmental biology.

Laubichler has compiled detailed analyses of certain periods of innovation, especially in developmental biology. He has extensive records of research breakthroughs and the scientists involved in them, dating back to the 1960s. Bliss used this data to create a mathematical filter that can detect certain patterns a citation network, ultimately identifying people who spurred innovation in developmental biology.

When she applied the construct to a network of citations produced from 1969 to 1980, she got a positive result. The filter pinpointed a couple of key individuals, and after cross-referencing with Laubichler's historical records, Bliss determined they were involved in innovation.

Next, the researchers applied the same filter to the developmental biology citation network from 1990 to 2000. Again, the results were positive, correctly identifying scientists involved in innovation. By analyzing the interactions among authors of scientific papers, the mathematical model serves as a kind of "formula for innovation," Bliss says.

The filter Bliss and Laubichler created has several promising applications. For example, being able to detect the emergence of innovation would allow funding agencies to provide resources or support to the right people at the right time.

"One application of this could be working with NSF to continuously track publications and apply the filters to these large networks and see where there are emerging patterns, and maybe detect them before they've emerged and identify those as areas of potential in the scientific community," Bliss says.

A next logical step in the research would be to apply the filter to citation networks of other fields, outside of developmental biology. Ultimately, researchers believe the results could provide evidence for the efficacy of interdisciplinary research.

"One of the things you actually see in publication networks is that a lot of times when there is a major change to the field, there is a set of fields that are touching each other, so authors from different areas end up working together," Bliss says.

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