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COMPLEXITY AND EMERGENT INNOVATION IN PUBLIC UNIVERSITIES

Dawn R. GILPIN

Dawn R. GILPIN

Associate Professor, PhD, Walter Cronkite School of Journalism & Mass Communication, Arizona State University, Phoenix, USA
E-mail: dgilpin@asu.edu

Abstract

This essay introduces complexity theory as a lens for examining public universities and their role in society, in particular regarding emergent innovation. The complexity principles of scale, interdependence, embeddedness, nonlinearity, and emergence identify possible paths for higher education institutions seeking to reinforce and expand their function in the community and their capabilities for producing new knowledge and novel forms of organizing. The case of Arizona State University's charter and design aspirations are used to illustrate how a complexity-aware university can be designed and operate as a force for positive social change.

Keywords: complexity, complex systems, social change, public administrations, universities.

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1. Introduction

While modern universities have arguably never been ivory towers of disengagement, in today's landscape of higher education the metaphor is even less apt: public universities, in particular, are deeply intertwined with a dense network of other institutions and constituencies (Shapin, 2012, pp. 14–17). The embedded and interdependent nature of such entities invites examination through the lens of complex systems, a theoretical framework that highlights interconnectedness and a dynamic of emergent innovation. For ten years, U.S. News & World Report has ranked Arizona State University (ASU) in the top spot for innovation among U.S. universities, nominated by peers in higher education across the country (Faller, 2024).

This essay introduces complexity theory as a lens for examining public universities and their role in society, in particular with regard to emergent innovation. The complexity principles of scale, interdependence, embeddedness, nonlinearity, and emergence identify possible paths for higher education institutions seeking to reinforce and expand their function in the community and their capabilities for producing new knowledge and novel forms of organizing. The case of Arizona State University's charter and design aspirations are used to illustrate how a complexity-aware university can be designed and operate as a force for social change.

2. Universities as complex systems

Approaching organizations such as universities as complex systems offers a perspective that can highlight ways to enhance their role in knowledge production, community building, and engagement, and serve as forces for positive change. These enhanced capabilities stem from a deeper understanding of what constitutes a complex system and the general principles of complexity theory.

2.1. Defining complex systems

Melanie Mitchell (2009) defined complex systems as those with a large number of interacting components that operate according to simple rules, which 'give rise to ... nontrivial emergent and self-organizing behaviors' (p. 13). These emergent properties constitute recognizable patterns of order and innovation (Tilebein, 2006, p. 1088).

Different explications of what qualities characterize a complex system exist in the scholarly literature, but some of the most agreed-upon key principles include scale, interdependence, embeddedness, nonlinearity, and emergence (see for example Gilpin and Murphy, 2008; 2010). The first three represent fundamental characteristics of the system, while the last two refer to properties and behaviors that the system exhibits as a result of the former. The primary focus of complexity theory is not on the actors that make up the system, but the dynamic relationships among them, the permeability of system boundaries, and the nonlinearity of internal and environmental changes over time. It is important to note that complex systems are necessarily situated in time and space, embedded as they are within

their own unique network and operating within a specific setting. They also exhibit path dependency, meaning it is important to understand the history of a given system in order to grasp the range of options available to it for emergence at any given moment (Colander and Kupers, 2014, p. 54).

A complex system therefore comprises a large number of interdependent actors—be they individuals, groups, organizations, institutions, or other entities—that meaningfully interact with one another in a particular spatiotemporal context. The outcome of these numerous situated interconnections can be difficult to predict since their interdependency often produces unexpected consequences. The resulting emergent properties can transform the configuration of the system itself, and produce significant change across its range of connections.

2.2. Robustness and innovation in complex systems

As noted above, the interactions among elements of the complex system and between these and the overall environment over time lead to emergent patterns. These interactions are typically guided by simple rules that 'produce complex behavior in hard-to-predict ways' (Mitchell, 2009, p. 13), and make for a robust, resilient, and adaptable system (Tilebein, 2006, p. 1095).

Both the system agents and the guiding rules thus serve as 'design levers' to produce outcomes that are robust and orderly but also generative, producing true innovation in the form of new knowledge and system reconfigurations (Tilebein, 2006, pp. 1095–1096).

2.3. Application to higher education

Whereas classic systems theory assumes a certain unity of purpose, one reason social scientists have been drawn to complexity theory as a lens in recent decades is that it allows for 'heterogeneity of purpose', which more fully reflects the nuances of human sociality and organizing (Rhodes *et al.*, 2010, p. 115). In another point of departure, the boundaries of complex systems elude clear definition, as the system is always changing, incorporating new elements, discharging others, evolving new rules, and responding to various internal and contextual developments. As a result, it can be more useful to conceive of complex organizational systems 'as an ongoing process and series of interactions rather than organization-as-autonomous-thing' (Gilpin and Murphy, 2008, p. 31).

These features are especially useful when approaching the idea of a university as a complex system, seeing as how they necessarily operate as part of inter-organizational networks constantly engaged in producing new knowledge that compels ongoing change and boundary spanning. What happens, then, if the university intentionally adopts a set of guiding principles that harnesses the tenets of complexity to stimulate innovation and community engagement by leaning even more heavily into interdependence, embeddedness, and a richly textured network of relationships? This is the example of Arizona State University and its New American University model.

3. The New American University model through a complexity lens

Organizational identity has been shown to serve an essential function in adaptability, as well as cohesion and sense of belonging among members and external constituencies (Gilpin and Miller, 2013). Complexity scholars have identified leadership as one of the principal drivers of organizational identity and complex emergence (Schneider and Somers, 2006, p. 358). Page (2011) also pointed out that while some emergent behavior in complex social systems represents evolutionary processes, 'economies and idea systems both evolve and are subject to creative changes by purposeful actors' (p. 80). It is thus useful to examine the case of a university that has made leadership and identity decisions conceptually rooted in principles of complexity.

3.1. Guiding doctrine of the New American University

In 2014 Arizona State University President Michael Crow launched a model called 'The New American University', enacting a change he had been working towards since first joining the institution in 2002 (Crow and Dabars, 2015). The launch formalized ASU's charter, which serves as the fundamental mission statement for every initiative undertaken by the university and its associated entities:

> *'ASU is a comprehensive public research university, measured not by whom it excludes, but by whom it includes and how they succeed; advancing research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural and overall health of the communities it serves'* (Arizona State University (a), undated).

This charter was accompanied by nine 'design aspirations' to operationalize the charter into actionable directives (Arizona State University (b), undated). Together, the charter and design aspirations provide a set of core principles to guide decision-making throughout the university. Table 1 highlights some of the parallels between these design aspirations and principles of complexity.

Table 1: ASU design aspirations and principles of complexity

ASU Design Aspirations	Related principle(s) of complexity
Leverage our place	Situatedness and embeddedness: emphasis on specific context(s)
Enable student success	Interdependence and emergence: students expand the relational network and help produce change
Transform society	Emergence and nonlinearity: seeking and rewarding transformational outcomes
Fuse intellectual disciplines	Interdependence: fields of knowledge cannot thrive in isolation
Value entrepreneurship	Emergence: valuing novel contributions
Be socially embedded	Embeddedness, situatedness and interdependence: local relational networks
Conduct use-inspired research	Situatedness, interdependence and emergence: knowledge networks and production lead to innovation
Engage globally	Embeddedness, situatedness and interdependence: global relational networks

Source: The author

The university charter and design aspirations can therefore be seen as complexity enablers, constituting a framework that explicitly creates the conditions for fostering emergent innovation based on principles of complexity. In the decade since their formal adoption, the university has collected accolades for the broad societal impact of its innovations (Arizona State University (c), undated; Faller, 2021). It is therefore worth taking a closer look at the impact of these guiding principles on the university's growth and development.

3.2. Scale and inclusive excellence

According to Colander and Kupers (2014), 'the more interconnected parts to a system, the more likely it is that the system is best analyzed as a complex system' (p. 46). ASU is one of the largest research universities in the United States. In fall 2023, nearly 150,000 students were enrolled in over 800 undergraduate and graduate degree programs, led by nearly 5,500 faculty members. Expanded access has a multiplier effect on enhancing innovation. Page (2011) emphasized that a multiplicity of actors, variation in relational ties, and diversity of configurations 'often enhances the robustness of complex systems' (p. 8).

ASU uses the term 'inclusive excellence' to concisely describe how the charter drives recruitment of students, faculty, and staff, transdisciplinary collaboration, and a broad range of institutional partnerships in pursuit of individual and collective achievement (Arizona State University (d), undated).

3.3. Example of emergent innovation for social change: Sustainability and global futures

The mandate to 'fuse intellectual disciplines' is driven by the understanding that the problems facing contemporary society are too multifaceted to be effectively handled by experts in any single field. Such so-called wicked problems are ones that 'defy efforts to delineate their boundaries and to identify their cause' (Rittel and Webber, 1973, p. 167). A group of ASU scholars recently wrote about the importance of establishing institutional structures that facilitate and support interdisciplinary work to enable scholars to engage in these types of collaborative projects (Trinh *et al.*, 2022).

One example of this disciplinary fusion and the accompanying strategic structural choices is ASU's adoption of sustainability as a core value. In 2020, the university announced it was creating the College of Global Futures to house a number of interdisciplinary programs aimed at addressing complex scientific and social problems. The college can be seen as an instance of structural emergence, both resulting from and accelerating systemic change. University president Michael Crow first convened a meeting of thought leaders in 2005 to explore the idea of refocusing the university around the urgent need to address issues of sustainability (Seckel, 2020). As of the present writing, the college includes the School of Sustainability (the first of its kind in the country, established in 2006), the School for the Future of Innovation in Society (2016), the School of Complex Adaptive Systems (2020), and the School of Ocean Futures (2023). It is also home to the Julie Ann Wrigley Global Futures Laboratory, widely known as GIOS (2019), an international research institute designed to 'operate like a medical center for the planet and its inhabitants'

through 'ongoing and wide-ranging exchange across all knowledge domains to address the complex social, economic and scientific challenges spawned by the current and future threats' (Arizona State University (e), undated).

Each school individually represents a novel configuration compared to traditional universities organized by siloed disciplines. For example, the School for the Future of Innovation in Society brings together experts in science and technology policy, global development, informatics, and other innovation-focused specialties. GIOS serves as a global hub to connect researchers, industry partners, and educators. An article celebrating the 15th anniversary of GIOS noted that over 500 scientists were engaged with wicked problems ranging from climate change to biodiversity, renewable energy, water issues, food systems, and other subjects (Seckel, 2020). Meanwhile, The Times Higher Education in 2024 ranked ASU as the top university in the United States for sustainable development goals (ninth globally) for the fifth year in a row (Times Higher Education, undated).

These initiatives represent a brief example of how ASU's complexity-aware design principles have encouraged the development of knowledge networks and community partnerships while advancing global engagement, social embeddedness, and entrepreneurship, all in service of producing principled social innovation.

4. Conclusion

This essay outlines the principles of complexity theory as applied to organizations. The central thesis is that approaching the university as a complex system illustrates a potential path forward for other public institutions seeking to leverage the power of complexity to produce meaningful social change and contribute productively to the communities with which they engage. ASU serves as an exemplar of a complexity-aware organization that fosters emergent innovation, community engagement, and organizing for knowledge-building and societal impact.

The implications for those working from a public administration perspective are significant. Positive transformation amid the range of wicked social and environmental problems the world is facing today will require multifaceted collaboration across institutions and communities, intense knowledge creation and sharing, and mobilization of networks. Public leadership need not be situated within traditional government institutions (Weber and Khademian, 2008, p. 342), and as demonstrated by ASU, public universities have the potential to lead society into a new era of productive evolution by effectively deploying complexity-enabling elements.

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