Computational Ecosystems: Tech-enabled Communities to Advance Human Values at Scale

My work advances the design of integrated socio-technical models that solve complex problems and advance human values at scale. Despite the continued development of individual technologies and processes for supporting human endeavors, major leaps in solving complex human problems will require advances in system-level thinking and orchestration. Toward this goal, I design, build, and study *Computational Ecosystems* that interweave community process, social structures, and intelligent systems to unite people and machines to overcome large challenges. Computational ecosystems integrate various components to support ecosystem function; the interplay among components synergistically advances desired values and problem solving goals in ways that isolated technologies and processes cannot. Taking a systems approach to design, computational ecosystems emphasize (1) computational thinking to decompose and distribute problem solving to diverse people or machines most able to address them; and (2) ecological thinking to create sustainable processes and interactions that support jointly the goals of ecosystem members and proper ecosystem function.

My research on computational ecosystems addresses the challenges of scaling up solutions that advance desired human values in the absence of technology that can overcome real-world constraints. For example, while a community may wish to cultivate learners who are autonomous, self-directed, and competent in tackling complex, real-world problems (i.e., its *values*), existing effective models such as apprenticeship "require a very small teacher-to-learner ratio that is not realistic in the large educational systems of modern economies [1]." While software can provide helpful prompts that support student thinking, no AI technology can replace the mentor in the foreseeable future [2]. Instead of waiting for a technological silver bullet or compromising on our values, computational ecosystems combine wedges of human and machine competencies into integrative technology-supported, community-based solutions that scale desired human values today.

For example, my research led the design of computational ecosystems to advance community-based planning and research training. A core value of inclusive, community-based planning is to recognize and advance the diverse goals of its members [3], but in practice, organizers often lack information about the diverse preferences, constraints and knowledge held by community members and tools for managing the complexity of planning. To resolve this tension, we introduced a computational ecosystem for *community-informed planning* that provides a general model for engaging various stakeholders in the planning process and mixed-initiative tools for organizers to refine plans using community input, system recommendations, and their tacit knowledge [4,5,6]. Applied to conference scheduling, we deployed the Cobi system at ACM conferences and produced three key outcomes: (1) our process engaged 1.5k+ community members through various phases of planning; (2) our mixed-initiative tools reduced organizers' planning time from 100 hours to 5 hours; and (3) organizers produced better schedules by resolving hundreds of previously hidden conflicts.

Similarly, to cultivate self-directed learners while overcoming the orchestration challenges of one faculty researcher mentoring 20+ students, we introduced Agile Research Studios (ARS)—a computational ecosystem that integrates and advances professional best practices and organizational designs, principles for forming effective learning communities, and design of social technologies [7,8]. A successful 3-year pilot hosted 50 mostly undergraduate students who led 25 research projects, published first-authored papers at top conferences, and won major ACM research competitions.

My ongoing work is to advance the system-level thinking embedded in these examples to provide scalable solutions to a diverse range of human concerns. We are currently designing two new computational ecosystems: *readily available learning experiences* (RALE) and *on-the-go crowdsourcing*. RALE transforms the entire web of professional code examples into opportunities for authentic learning. On-the-go crowdsourcing motivates large numbers of people to contribute to solving local, communal problems in their existing routines. Beyond these examples, I am beginning to develop principles and methods for designing computational ecosystems for broader applications.

References

[1] Allan Collins and Manu Kapur. Cognitive apprenticeship. In R. K. Sawyer (Ed.) Cambridge Handbook of the Learning Sciences (2nd Edition). Cambridge University Press, 2014.

[2] Sanna Jarvela and Allyson F. Hadwin. New frontiers: Regulating learning in CSCL. Educational Psychologist 48, 1 (2013), 25–39.

[3] Paul Davidoff. Advocacy and pluralism in planning. Journal of the American Institute of planners 31.4 (1965), 331–338.

[4] Juho Kim, Haoqi Zhang, Paul André, Lydia B. Chilton, Wendy Mackay, Michel Beaudouin-Lafon, Robert C. Miller, and Steven P. Dow. Cobi: A Community-Informed Conference Scheduling Tool. In Proceedings of the 26th Annual ACM symposium on User Interface Software and Technology (UIST 2013), 173–182.

[5] Lydia Chilton, Juho Kim, Paul André, Felicia Cordeiro, James Landay, Dan Weld, Steven P. Dow, Robert C. Miller, Haoqi Zhang. Frenzy: Collaborative Data Organization for Creating Conference Sessions. In Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI 2014), 1255–1264.

[6] Cobi: Communitysourcing Large Scale Conference Scheduling. http://projectcobi.com

[7] Haoqi Zhang, Matthew W. Easterday, Elizabeth Gerber, Daniel Rees Lewis, and Leesha Maliakal. Agile Research Studios: Orchestrating Communities of Practice to Advance Research Training at Scale. Proceedings of the 20th ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW 2017), 220–232.

[8] Agile Research University: Supporting Authentic Research Experiences at Scale. http://agileresearch.io