Understanding Complex and Coupled Systems to Educate Tomorrow’s Systems Thinkers

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Jake Grohs, Assistant Professor (faculty lead)
Department of Engineering Education, Virginia Tech
Affiliate Faculty, Learning Sciences and Technologies; Biomedical Engineering and Mechanics

Konstantinos P. Triantis, Professor
Department of Industrial and Systems Engineering, Virginia Tech
Affiliate Faculty, Civil and Environmental Engineering

David Knight, Assistant Professor
Department of Engineering Education, Virginia Tech
Affiliate Faculty, Higher Education; Human and Computer Interaction

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Department of Industrial and Systems Engineering, Virginia Tech

Gary Kirk, Director
VT Engage: The Community Learning Collaborative
Affiliate Faculty, School of Public and International Affairs
Professionals in today’s workforce must make sense of and consider complex coupled systems so as to improve the performance and outcomes of these systems. However, research shows that professionals do not understand the fundamentals of complexity that underlie these systems (Baghaei Lakeh & Ghaffarzadegan, 2015; Kapmeier, Happach, & Tilebein, 2016; Sterman, 2010). We have gathered a multi-disciplinary faculty team with expertise in systems thinking, public policy, learning sciences, measurement science, and higher education, to operationalize critical systems thinking competencies, develop and validate assessment tools, study cognitive barriers associated with the understanding of system complexity, and leverage these collective competencies to improve undergraduate and graduate education.

**Vision Statement:** We envision Virginia Tech as the preeminent leader in research to understand complex and coupled systems and to translate that research into actionable improvements in system design of engineered systems, enterprise transformation, and educational systems. In past work, we have developed assessment tools designed to evaluate student systems thinking competencies in both discipline specific (i.e., Industrial and Systems Engineering context) and domain general (i.e., co-curricular programs). Our ongoing research investigates the cognitive barriers that impede the understanding of the structure and behavior of complex coupled systems for both students and working professionals. This research will develop methods and tools that can scaffold students’ and working professionals’ understanding of system complexity. We believe Virginia Tech has core competencies at the intersection of complex systems, systems thinking, engineering education, and policy analysis. Our vision is to build on and link these competencies, expand our team, further advance our multi-disciplinary research, and integrate research efforts and findings into specific curricula. The proposed concept benefits from engineering faculty expertise in systems thinking and policy research associated with the System Dynamics and System Performance Labs, engineering education expertise translating data on educational systems and learning analytics into actionable improvements from the VT DEEP Lab, and expertise in the application of systematic approaches to collaborative problem solving in community contexts from VT Engage.

Products from our investigations will be used as teaching tools for undergraduate and graduate students and will provide mechanisms for assessing interdisciplinary programs of study, such as those envisioned by the Destination Areas and Pathways to General Education at Virginia Tech. Our team has conducted pilot studies using the Systems Thinking for Engaging Problem Solvers (STEPS) measure to engage undergraduates in systems thinking and assess high-impact experiential learning programs, such as the Rising Sophomore Abroad Program. Further, STEPS has been implemented in SPIA 2984: Community Systems Thinking, and previously in LDRS 1015: Exploring Citizen Leadership as part of the SERVE Living Learning Community as both an assessment and a teaching tool. This Community Systems Thinking course (now SPIA 1024) has recently been approved as part of a proposed Pathways Minor in Community Systems and Engagement.

**Relevance:** Our proposed concept is aligned with goals of the GSS DA, which focuses on “critical problems that cross the nexus of natural and human systems.” In order to find sustainable solutions for human-made problems for the environment, decision makers need to understand the structure and behavior of complex systems. A key research element of our concept focuses on cognitive barriers that prohibit problem solvers from understanding system complexity when they are making analytical interventions that lead to effective interventions.

As part of our response to this request for concepts, we will conduct a pilot study. During our past year of collaboration, we developed an environmental vignette, referred to as the Lake Urmia case that describes a human-environment coupled system. Lake Urmia (appendix II) was the largest lake in the Middle East but the area of the lake shrank by 88% from 1972 to 2014. This case is a real-world example of an environmental catastrophe where a growing population, in conjunction with human-driven changes, has led to the disappearance of a lake that was a vital resource for humans and a habitat for diverse species for thousands of years.

In addition to the Lake Urmia case, we will further expand work with the STEPS measure (appendix II), which has already been used in interdisciplinary settings and for co-curricular program assessment. The STEPS scenario consists of a vignette problem scenario, a series of written prompts to elicit student reasoning processes, and a scoring rubric to rate responses according to targeted constructs (e.g., Stakeholder...
Awareness, Unintended Consequences). The STEPS measure uses a realistic community-level problem with intertwining social, ethical, political, and environmental elements embedded within the vignette.

In our pilot study, we will examine engineering students’ and professionals’ ability to understand and analyze the case. Twenty engineering students, twenty non-engineering students, and twenty engineering professionals will be asked to answer the questions in the vignette and their responses will be analyzed to determine their understanding of complexity. After the experiment with the vignette, we will interview the respondents to find out how they answered questions, which cognitive skills they used, and how and where they developed these skills.

This concept proposal will provide preliminary input for the proposals that we will submit in the future to the following programs:

- The Robert Wood Johnson Foundation
- The Bill & Melinda Gates Foundation
- The Alfred Sloan Foundation
- NSF programs including Improving Undergraduate STEM Education (IUSE), Research in the Formation of Engineers (RFE), System Science (SYS), Science of Learning (SL), and Behavioral and Cognitive Science (BCS)
- Behavioral and Social Science Research (OBSSR) at NIH

In addition to GSS, this concept is related to the other destination areas which aim to “identify and solve complex, 21st-century problems.” Specifically, this concept will benefit the Data Analytics and Decision Sciences DA by demonstrating how students and professionals analyze the data in our vignettes, what cognitive skills they use, and how and where they obtain these skills. In addition, this concept is related to the Intelligent Infrastructure for Human-centered Communities DA because “smart, healthy, and sustainable cities and communities” cannot be designed if the policy makers and engineers do not understand the complexity underlying interdependent “intellectual infrastructures.” The concept will also provide primary tools for “understanding security as an integrated system of values, capabilities, and preparedness,” which is the focus of the Integrated Security DA. Moreover, this concept is useful for the Policy Strategic Growth Area because our study will inform what prohibits policy makers from understanding the complexity of the systems they manage and how their decisions can be improved.

Curriculum Opportunities:

Multiple courses at VT can benefit from our research as we build a multidisciplinary center for systems thinking. ENGR 5104 provides the conceptual and technical knowledge necessary to conceptualize dynamic problems, formulate appropriate simulation models, and use models to understand sociotechnical systems and develop effective policy interventions. ISE 5015 focuses on organizational change using a holistic systems perspective and systems thinking. ISE 5984 provides an overview of healthcare systems and focuses on the tools that systems thinking and system dynamics modeling offer for understanding complexity in healthcare systems and for designing effective policy interventions. In addition, ISE 5124, which focuses on improving the quality and reliability of organizations and ISE 5144, which presents the principals of performance measurement and evaluation, will benefit from our concept. Within Engineering Education, this project will support ENGE 1644: Global Engineering Practice: Leadership and Culture, which emphasizes contextual influences on problems and possible solutions, as well as ENGE 1215: Fundamentals of Engineering 1, which introduces students to ill-structured problems.

Most importantly, our concept can provide assessment tools for evaluating courses within destination areas and strategic growth areas, Pathways to General Education minors and courses, and high-impact experiential learning programs such as the Rising Sophomore Abroad Program (currently enrolls 135 undergraduate engineers).

We foresee designing two new courses at the undergraduate and graduate levels. First, an undergraduate course titled Policy Design for Human-Natural Coupled Systems will cover 1) the basics of human-natural coupled systems, 2) the basics of systems thinking and modeling of complex systems, 3) analyzing complexities of coupled systems with an emphasis on the analytical, decision making (DA), policy (SGA), security (DA), and data (DA) challenges one faces, 4) case studies of coupled systems that builds on specific examples of
interdependent infrastructure systems and processes (intelligent infrastructure DA) for example the interdependence of infectious disease, water, food and agriculture as demonstrated by the Lake Umria vignette, and 5) policy design for coupled systems. Students will use simulation models such as MIT’s Greenhouse Gas Emissions Simulator¹, as learning platforms. The course will be co-taught by systems, policy, and environmental faculty members, and during the first several years will be closely monitored and managed by engineering education faculty. Second, a graduate level course will be designed on Dynamic Modeling of Human-Natural Coupled Systems. This course will go into detail about the mathematical modeling of coupled systems. It will cover 1) the basics of human-natural coupled systems, 2) the system dynamics and agent-based modeling of complexity for coupled systems focusing on capturing the requisite decision making (Decision and Data Analytics DA), policy (SGA) implications, security challenges (Security DA), and validation and verification using analytical approaches and field data (Data Analytics DA) challenges one faces, 3) case studies of coupled systems, and 4) simulation-based policy design for coupled systems.

Description of Resource Needs: We aim to advance cutting edge research while directly infusing findings into curricular and co-curricular education programs at Virginia Tech. A preliminary hiring plan to increase the interdisciplinary capacity of the team while building upon both research and education missions includes:

- Tenure-track/Tenured Faculty with the following expertise to complement our existing team:
  - Cognitive Neuroscientist to expand our research into investigating cognitive barriers to complex systems thinking through neuroimaging research (e.g., functional near-infrared spectroscopy (fNIRS), functional magnetic resonance imagining (fMRI)).
  - Behavioral Economist to teach the most recent findings on psychological, social, and emotional factors that impact the economic decisions of the end-users of a complex system and to expand the theories of behavioral economics for global coupled systems.
  - Philosopher/Historian of Systems Science to evolve the theories of systems science.
- Professor of Practice with significant industry, government, or non-profit sector experience to actively teach across the courses identified earlier in the proposal.
- A/P Faculty Director of the Center for Educating Systems Thinkers to facilitate interdisciplinary research, curricular design and implementation, and advance the team’s pursuit of extramural funding across the diverse settings.

¹ https://www.climateinteractive.org/tools/mits-greenhouse-gas-simulator/
NAME: Ghaffarzadegan, Navid

eRA COMMONS USER NAME (credential, e.g., agency login): navidg

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<td>BS</td>
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<td>Sharif University of Technology, Tehran, Iran</td>
<td>MBA</td>
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<td>Management (System Dynamics)</td>
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<tr>
<td>State University of New York at Albany, NY</td>
<td>PhD</td>
<td>12/2011</td>
<td>Public Policy (System Dynamics)</td>
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<tr>
<td>MIT, Engineering Systems Division, Cambridge, MA</td>
<td>Post-Doc</td>
<td>08/2013</td>
<td>System Dynamics</td>
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A. Personal Statement

Dr. Navid Ghaffarzadegan is a system dynamicist by training, and currently Assistant Professor of Industrial and Systems Engineering at Virginia Tech. System dynamics is a systems thinking and simulation method for analyzing complex systems. Navid received his PhD from the Public Administration and Policy program of SUNY-Albany, where he conducted research at the head quarter of the System Dynamics Society in collaboration with well-known experts of the field. He is the recipient of several best paper awards, including the Lupina Young Researcher Award for Health System Dynamics. As a postdoctoral researcher he conducted his research at MIT for two years, which was funded through an NIH/NIGMS grant on modeling science workforce development in biomedicine.

Navid’s research interests include applications of system dynamics modeling and other simulation techniques in management and public policy contexts. One example of his studies is modeling science workforce and science policy. In this line of research he is studying how government spending on science can affect scientific activities and what type of policies maintain strong science workforce. This research has been supported by NIH. He has also conducted a wide range of experiments to study cognitive barriers for understanding basic elements of complex systems. His studies have resulted in several publications and conference papers as well as invited lectures in various NIH institutions and health research centers and hospitals.

On the teaching side, Dr. Ghaffarzadegan has been offering complex systems related courses. Examples include management systems, innovation, and organizational change, systems thinking, and system dynamics. He has also developed and offered an undergraduate level course on systems thinking.

Navid is currently the Associate Editor of the System Dynamics Review. He is the recipients of various awards including the College of Engineering’s excellence award for outstanding new Assistant Professors.

B. Positions and Honors

Positions and Employment
2013–present  Assistant Professor, Grado Department of Industrial & Systems Engineering, Virginia Tech

Other Experience and Professional Memberships

2016-  Associate editor of *System Dynamics Review*


2006-  Member of the Academy Health, Academy of Management (AOM), Association for Public Policy Analysis and Management (APPAM), Institute for Operations Research and the Management Sciences (INFORMS), System Dynamics Society, Society of Judgment and Decision Making.

2012-  Recent relevant invited lectures: Tehran University (2014), Battelle Center for Science & Technology Policy, Ohio State University (2013); Hematology Workforce Working Group, NIH Heart, Lung and Blood Institute (2013); Heart Division; NIH Heart, Lung and Blood Institute (2013); Office of Behavioral and Social Sciences Research; National Institutes of Health (2013); Virginia Tech, Department of Industrial and Systems Engineering (2013); MIT, Sloan School of Management (2013); Yale School of Public Health (2012); George Washington University (2013); John Glenn School of Public Affairs, The Ohio State University (2012); MIT, SENSEable City Lab (2012); Albany Medical Hospital (2011)

Honors

2016   College of Engineering’s excellence award for outstanding new Assistant Professors
2011   Lupina Young Researchers Award in Health System Dynamics ($2,500)
2011   Best Student Paper awards at International System Dynamics Conference
2008   Barry Richmond Award in System Dynamics
2008   Runner-up for the best paper awards at International System Dynamics Conference
2006-2011  System Dynamics Society full scholarship for five years.

C. Contributions to Science

1. **Modeling of Complex Systems**

During the past 10 years, I have been developing system dynamics models to analyze different complex systems. One major application context has been science policy. Started in 2011, I have been employing a combination of systems approaches, mathematical models, and data analyses to study the “science ecosystem.” In collaboration with my colleagues at the Ohio State University and MIT, we have defined a measure of population growth in academia, the basic reproduction number ($R_0$), and estimated this measure for various science and engineering fields. We have looked at the effects of change in research funding on performance of scientists and research enterprises uncovering unintended consequences of abrupt changes (increase or decrease) in funding. We have analyzed the population of postdocs in different fields bringing insights into how to efficiently maintain science workforce capacity. This research has helped to understand some of systemic shortcomings of current science policies and led us articulate different aspects of education as a complex system. Examples of publications in this domain include:


2. **Understanding complex systems**

Why people have difficulties understanding basic blocks of complex systems? This question has led to several experimental studies where participants are hired and their response to a specific complex task (the department store task) are examined. We have conducted a set of experiments with undergraduate students at Virginia Tech, as well as the general public on Amazon Mechanical Turk. Through these studies, we have introduced psychological interventions that can trigger analytical thinking and increase participants’ performance in our experiment. Examples of publications:


D. **Research Support**

**Ongoing Research Support**


**Past Research Support**

NAME: Jacob R. Grohs

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Assistant Professor of Engineering Education

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<td>B.S.</td>
<td>05/2008</td>
<td>Engineering Science and Mechanics</td>
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<td>Virginia Tech, Blacksburg, VA</td>
<td>M.S.</td>
<td>05/2009</td>
<td>Engineering Mechanics</td>
</tr>
<tr>
<td>Virginia Tech, Blacksburg, VA</td>
<td>M.A.Ed.</td>
<td>12/2012</td>
<td>Education, Curriculum, &amp; Instruction (Educational Psychology)</td>
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<tr>
<td>Virginia Tech, Blacksburg, VA</td>
<td>PhD</td>
<td>05/2015</td>
<td>Education, Curriculum, &amp; Instruction (Educational Psychology)</td>
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A. Personal Statement

Leveraging my background in learning sciences and past professional roles as an instructor of large mechanics courses and an administrator focused on community-engaged learning and research, I focus my research efforts in two primary areas:

1. Learning and Assessment of Complex Socio-Cognitive Reasoning Capacities—
   I strive to build learning theory about the processes through which individuals reason through wicked problems and the ways such capacities develop over time.

2. Community-Engaged Change to Improve Engineering Education Systems—
   I collaborate with diverse stakeholders to address broadening participation goals in engineering and to better the quality of undergraduate engineering education.

Sample publications:


B. Positions and Honors

Positions and Employment

2009-2012  Assistant Director, VT Engage: The Community Learning Collaborative, Virginia Tech
2012-2014  Associate Director, VT Engage: The Community Learning Collaborative, Virginia Tech
2014-2015  Instructor, Department of Biomedical Engineering and Mechanics, Virginia Tech
2015- Assistant Professor, Department of Engineering Education, Virginia Tech
2015- Affiliate Faculty, Biomedical Engineering and Mechanics, Virginia Tech
2015- Affiliate Faculty, Learning Sciences and Technologies, Virginia Tech

Other Experience and Professional Memberships
Member, American Educational Research Association
Member, American Society for Engineering Education
Panel Reviewer, National Science Foundation

Honors
2015 American Assoc. of Colleges and Universities (AAC&U) K. Patricia Cross Future Leaders Award

C. Contributions to Science

I am co-PI on one NSF grant and PI or co-PI on institutional grants. These projects represent strong interdisciplinary collaborations. Research activities are summarized as follows:

Learning and Assessment of Complex Socio-Cognitive Reasoning Capacities

Governmental bodies and industry increasingly demand that universities develop graduates capable of tackling broad complex problems and who can integrate ideas across multiple disciplines to invent new solutions. Yet, with the field of engineering education still early in its development, we need new theory about the processes through which individuals reason through these wicked problems and the ways such capacities develop over time. To this aim, I have led development of a scenario-based tool and associated scoring rubric designed to measure systems thinking competency in an interdisciplinary setting and am working to extend work with neuroimaging during engineering problem-solving and design tasks into the more complex environment of the systems thinking research space.

Sample publications:

Community-Engaged Change to Improve Engineering Education Systems

Inequities and inefficiencies in the engineering education system are distressing and difficult to address. In some cases, research may have identified the problems but proposed solutions are difficult to implement or do not resolve issues in practice. In other cases, there may be so many intervening factors that we do not really even understand the problem, much less are we able to propose viable solutions. These challenges lead me to focus on three areas of collaborative research with diverse stakeholders and partners:

- **Broadening Participation in Engineering: High Schools in Virginia**—I am co-PI on an NSF-funded project with EngE and Human Development colleagues that will use a existing longitudinal statewide data set to examine where and why there are demographic variations across high schools in the proportion of students who fit an engineering academic profile but do not enroll in an engineering major.
- **Broadening Participation in Engineering: Better Serving Appalachian Youth**—I have led several proposals aimed at leveraging research on career choices of Appalachian youth in order to design community-engaged collaborative interventions in schools and informal settings. This research has involved partnerships with


the Girls Science Camps of the Science Museum of Western Virginia (SMWV), faculty from the Institute for Creativity Arts and Technology, Dr. Gary Kirk from VT Engage, and industry and school partners in Wythe, Giles, and Bedford counties.

- **Improving the Quality and Efficiency of Undergraduate Engineering Education: Revitalizing Feedback Loops**—Evidence indicates that factors such as large class sizes and unchanging instructional strategies in gatekeeping courses continue to create significant barriers to student success and persistence. Past research I’ve conducted has led to three NSF proposals currently under review.

**Sample publications:**


**D. Additional Information: Research Support and/or Scholastic Performance**

**Selected Competitive grants**

- **Gatekeepers to Broadening Participation in Engineering: Investigating variation across high schools comparing who could go versus who does go into engineering.** NSF, EEC-1647928. $503,093, 01/17-12/19. Co-PI (30%). PI: Knight, D. Co-I: Matusovich, H., Bradburn, I.
NAME: Hosseinichimeh, Niyousha

eRA COMMONS USER NAME (credential, e.g., agency login): HNIYOU4

POSITION TITLE: Assistant Professor of Management Systems Engineering

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<td>University at Albany, State University of New York, The Rockefeller College of Public Affairs and Policy, Albany, NY</td>
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A. Personal Statement

The proposed project aims to use the system dynamics (SD) modeling approach to examine feedback mechanisms through which different trajectory classes of Riding With an Impaired (RWI) driver and Driving While Impaired (DWI) are developed and lead to different adulthood outcomes (i.e., higher education enrollment, employment, and health). I have the expertise and experience to lead the SD modeling as a Co-Investigator on the current proposal, given my SD modeling experience in multiple projects.

In an R21 project, I used the SD methodology to investigate the feedback mechanisms underlying major depressive disorder. I developed an SD model of the hypothalamic–pituitary–adrenal (HPA) axis, and calibrated the model (Niyousha Hosseinichimeh, Rahmandad, & Wittenborn, 2015). In addition, I used the SD method to quantify the reciprocal relations among stress, depression, and rumination, to examine the progression of depression for different types of patients, and to investigate the impact of interventions on depressive symptoms. Our team also developed the first causal loop diagram of feedback processes of depression (Wittenborn, Rahmandad, Rick, & Hosseinichimeh, 2016).

Currently, I am leading another SD project funded by the Ohio State Department of Health. The project aims to develop an SD model of infant mortality in Ohio and examine different interventions for reducing the death of infants, especially among racial and economically disadvantaged groups. In summer 2016, Drs. David Andersen, George Richardson, Rod MacDonald (my collaborators in this project) and I conducted a group model building (GMB) workshop in Ohio to set the model boundaries, develop the model structure, and identify key interventions. In addition, we expanded GMB techniques to elicit parameter values and effect sizes from subject matter experts and implemented those techniques successfully in the GMB session conducted in Ohio (N. Hosseinichimeh et al.).

Finally, I have expertise extending methodological tools for SD modeling. My research expanded the system dynamics toolbox for modeling complex systems in areas with few data points over time. In many disciplines, panel datasets include many units (e.g., individuals) at only a few points in time, which makes it extremely
difficult to calibrate a dynamic model. I introduced a simulation based estimation method, *indirect inference*, to the SD community by adapting the method for calibration of our SD model of depression (Niyousha Hosseinichimeh, Rahmandad, Jalali, & Wittenborn, 2016).

**B. Positions and Honors**

*Positions and Employment*

- 2008-2012 Teaching Assistant, Rockefeller College of Public Affairs, State University of New York at Albany
- 2010-2012 Instructor, Rockefeller College of Public Affairs, State University of New York at Albany
- 2011-2012 Intern at the Office of Medicaid Inspector General (OMIG)
- 2013-2015 Postdoctoral Associate, Grado Department of Industrial & Systems Engineering, Virginia
- 2016-present Assistant Professor, Grado Department of Industrial & Systems Engineering, Virginia Tech

*Other Experience and Professional Memberships*

- 2010- Member of System Dynamics Society
- 2010- Member of the Association for Public Policy Analysis and Management
- 2010- Member of the Institute of Industrial Engineers
- 2013- Reviewer for *System Dynamics Review*
- 2013- Reviewer for *Mathematical Bioscience*
- 2016- Grant reviewer for the National Institutes of Health

*Honors*

- 2008-2010 Scholarship from University of Albany, State University of New York
- 2010 Pi Alpha Alpha Honor Society
- 2010 Excellence in Graduate Student Teaching Award, University at Albany, State University of New York, The Rockefeller College of Public Affairs and Policy
- 2011 Heikoff Scholarship Award, University at Albany, State University of New York, The Rockefeller College of Public Affairs and Policy
- 2012 Excellence in Graduate Student Teaching Award, University at Albany, State University of New York, The Rockefeller College of Public Affairs and Policy
- 2012 Heikoff Scholarship Award, University at Albany, State University of New York, The Rockefeller College of Public Affairs and Policy

**C. Contributions to Science**

1. **Modeling Dynamics of Depression**

   In an R21, we uniquely contributed to the depression literature by capturing complex feedback mechanisms that contribute to depression including biological, cognitive, social, and environmental factors. In addition, I compared models of the hypothalamic–pituitary–adrenal (HPA) axis, identified the best performing model, improved, and recalibrated the model. Furthermore, I developed the first individual level model of depression that captured the reciprocal relations among stress, depression, and rumination. After calibrating the model using a dataset of 661 individuals and the indirect inference method, I examined the progression of depression for diverse patients under different conditions and investigated the impact of a cognitive based intervention on
the development of depression for different individuals in a simulation environment. Our R21 resulted in the following publications and manuscripts.


2. **Impact of Public Policies on Emergency Department Utilization**

Emergency department (ED) utilization has increased in the U.S. and has led to ED overcrowding. ED overcrowding causes adverse clinical outcomes and it also signals problems in other parts of the healthcare system. Governmental policies can impact ED utilization by expanding health insurance, designing interventions such as disease management, cost sharing for public health coverage, and establishing community health centers in underserved areas. In prior research, I examined the effect of the Massachusetts healthcare reform, which expanded health coverage in that state, on ED utilization. In addition, my research found that ED use varies substantially across states; and I showed which characteristics are associated with higher ED use at the state level. Finally, I used administrative data on New York to study why Medicaid patients use EDs more than patients with other health coverage.


**List of Published Work**


D. Research Support

**Ongoing Research Support**

Ohio State Department of Health Joshua Hawley (PI) 05/2016-07/2017

This project aims to develop an SD model of infant mortality in Ohio and test the impact of multiple interventions on the rate of infant mortality in the state, specifically among racially diverse groups. Our team ran a group model building session to elicit feedback loops and the structure of the system from the subject matter experts and policy makers. I have developed an SD model of infant mortality, calibrated the model with administrative data, and simulated it to investigate the impact of interventions.
NAME: Kirk, Gary Richard

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Director, Pathways Programs (SPIA) & Faculty Director, Community Engagement (VT Engage)

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<td>Ecology &amp; Evolutionary Biology</td>
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<td>05/2000</td>
<td>Public &amp; International Affairs</td>
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<tr>
<td>Virginia Tech (Blacksburg, VA)</td>
<td>Ph.D.</td>
<td>12/2004</td>
<td>Environmental Design &amp; Planning</td>
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A. Personal Statement

As the director of a university-level center focused on service learning and community engagement, I developed an interest in advancing scholarship at the nexus of systems science and community development. Currently, I lead several curricular and programmatic efforts to integrate systems thinking skill development in undergraduate programs focused on community engagement and civic agency. I was recently appointed as director of the Community Systems & Engagement minor in the School of Public & International Affairs and piloted a new course in Community Systems Thinking in spring 2017. I bring relevant experiences to the proposal to build a Center for Educating Systems Thinkers, including academic administration, teaching, and research spanning a broad range of domestic and global policy arenas.


B. Positions and Honors

Positions and Employment

2002-2005 Associate Director, Institute for Distance & Distributed Learning, Virginia Tech, Blacksburg, VA
2005-2006 Visiting Assistant Professor of Political Science, James Madison University, Harrisonburg, VA
2006-2011 Assistant Professor of Public Policy & Administration, James Madison University, Harrisonburg, VA
2009-2011 Director of Programs in Public Policy & Administration, James Madison University, Harrisonburg, VA
2011-2017 Director, Center for Student Engagement & Community Partnerships-VT Engage, Virginia Tech, Blacksburg, VA
2017-present Faculty Director of Community Engagement, VT Engage, Virginia Tech, Blacksburg, VA
2017-present Affiliate Faculty, School of Public & International Affairs, Virginia Tech, Blacksburg, VA
2017-present Director of Pathways Programs, School of Public & International Affairs, Virginia Tech, Blacksburg, VA

Other Experience and Professional Memberships
2001-2009 Panel Reviewer, Distinguished Budget Awards, Government Finance Officers Association
2003-present Member, American Society of Public Administration
2009-2011 Executive Committee, Small Programs Section, National Association of Schools of Public Affairs & Administration
2016-present Member, Association for Experiential Education
2016 Institutional Lead, Institute for Integrative Learning & the Departments, Association of American Colleges & Universities
2017 Panel Reviewer, National Days of Service, Corporation for National & Community Service
2017-present Associate Editor, Journal of Experiential Education

Honors
2017-2019 Pathways Faculty Scholar, Virginia Tech, Blacksburg, VA
2006-2007 Madison Teaching Fellow, Center for Faculty Innovation, James Madison University, Harrisonburg, VA
2003 Provost’s Award for Excellence in Outreach & Engagement, James Madison University, Harrisonburg, VA
2002-2005 Fellow of the Academy of Leadership Excellence, Virginia Tech, Blacksburg, VA
2000 Virginia Citizen Planning Award, Virginia Planning Association

C. Contribution to Science

Systems Thinking Competency for Civic Agency and Community Development
My research interests have evolved to consider the role service learning and community engagement experiences have in students’ development of civic competencies and transferable thinking skills. Most of my recent research has revolved around a concept dubbed community systems thinking. Several current projects focus on operationalizing this concept and developing flexible tools for measuring it with the goal of refining educational programs that effectively prepare students to address ill-structured and wicked global problems.

Relevant Activities

Dynamics of Community Infrastructure and Collective Action
I have several ongoing and emerging research projects that seek to understand the relationship between community capacity and effectiveness of community-level change and individual quality of life. This work draws on my interests in community-university partnerships; the role of higher education institutions in society; nonprofit studies and community development; program evaluation and strategic planning; and assessment of student learning outcomes. Current projects relate to the role of partnerships and collective action in several policy contexts and issue frames, including food security, refugee resettlement, programs for at-risk youth, and urban poverty.

Relevant Activities


D. Additional Information: Research Support and/or Scholastic Performance

**Ongoing Support**

Pathways to General Education Grant, Virginia Tech 01/01/17-12/31/18

Community Systems & Engagement Minor

The goal of this project is to develop and gain approval for four courses and a new minor, housed in the School of Public & International Affairs, linking together concepts from systems theory, civic agency, and sociopolitical context. The minor will meet general education requirements and serve students from all majors.

Role: PI

**Completed Support**

Institute for Infrastructure & Information Assurance Research Grant  Stephens (PI) 08/15/09-05/10/10

Local Emergency Planning Committees

The goal of this project was to study the utility and effectiveness of federally-mandated committees (i.e., LEPCs) to plan an all-hazards approach to community-level disaster preparedness and response.

Role: Co-PI

OJJDP 2011-JU-FX-0002  Kirk (PI) 10/01/10-09/30/13

Testing the Impact of Mentor Training and Peer Support on the Quality of Mentor-Mentee Relationships and Outcomes for At-Risk Youth

The goal of this project was to develop evidence-based mentor training materials and to conduct a quasi-experimental, longitudinal study of their effects on mentors and at-risk youth mentees.

Role: PI

CNCS 12B1HVA002  Kirk (PI) 08/15/12-08/14/14

Remember Serve Learn [9/11-4/16]

The goal of this project was to develop service programming connecting university students, veteran and active duty military personnel, and regional communities to promote commitment to volunteerism and civic engagement.

Role: PI

CNCS 13VSSVA001  Kirk (PI) 11/04/12-09/03/16

Community Partnership VISTA Network

The goal of this project was to build capacity in poorly resourced nonprofit organizations in the New River Valley in a range of projects focused on poverty reduction and alleviation. The program placed over 20 full-time VISTA members on projects related to food security, transportation, housing, and education.

Role: PI

CNCS 13AFHVA0010008  Kirk (PI) 09/07/14-09/06/16

VT Engage AmeriCorps Network

The goal of this project was community capacity building in two key areas: disaster preparedness and early childhood literacy. The program partnered VT Engage with the American Red Cross and Smart Beginning to place 27 AmeriCorps members in regional partner agencies.

Role: PI
NAME: David B. Knight

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Assistant Professor of Engineering Education

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<th>Completion Date MM/YYYY</th>
<th>FIELD OF STUDY</th>
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<td>B.S.</td>
<td>05/2006</td>
<td>Environmental Sciences</td>
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<td>University of Virginia, Charlottesville, VA</td>
<td>M.S.</td>
<td>05/2009</td>
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<tr>
<td>University of Virginia, Charlottesville, VA</td>
<td>M.U.E.P.</td>
<td>05/2009</td>
<td>Urban &amp; Env. Planning</td>
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<tr>
<td>Pennsylvania State University, University Park, PA</td>
<td>PhD</td>
<td>05/2012</td>
<td>Higher Education</td>
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<tr>
<td>University of Queensland, Brisbane, Australia</td>
<td>Postdoctoral</td>
<td>07/2013</td>
<td>Engineering Education</td>
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A. Personal Statement

I lead the Data Enlightened Educational Practice (DEEP) Lab at Virginia Tech, which is comprised of an interdisciplinary team of doctoral students who work toward improving the efficiency, effectiveness, and inclusiveness of the engineering education system. Spanning the “grade school-to-graduate school” continuum, our work tends to be at the macro-scale, and we investigate multiple aspects of the system (i.e., curriculum, co-curriculum, and organizational contexts) to understand how to help students achieve a variety of outcomes. Three themes characterize our efforts:

1) Investigate organizational contexts, educational environments, and student experiences that support the development of diverse engineers who can become interdisciplinary problem-solving leaders across global contexts.
2) Identify mechanisms to enhance existing organizational decision-making processes through the incorporation of local data.
3) Leverage existing, large-scale data sets or collect new data in innovative ways to create intelligent feedback loops by connecting data, processes, and outcomes.

Sample publications:
B. Positions and Honors

Positions and Employment

2011-2012  Researcher, Ctr for the Study of Higher and Postsecondary Education, University of Michigan
2012-2013  Postdoctoral Fellow, School of Civil Engineering, University of Queensland, Australia
2013-   Assistant Professor, Department of Engineering Education, Virginia Tech, Blacksburg, VA
2013-   Affiliate Faculty, Higher Education, Human-Computer Interaction, Virginia Tech
2013-   Director of International Engagement, Department of Engineering Education, Virginia Tech

Other Experience and Professional Memberships

Board Member, Educational Research Methods Div, Amer Society for Engineering Education
Member, American Educational Research Association
Panel Reviewer, National Science Foundation

Honors

2010   Best Paper: Educational Research and Methods Div, American Soc of Engineering Education
2011   Best Paper: Women in Engineering Division, American Soc of Engineering Education
2012   Best Paper: Educational Research and Methods Div, American Soc of Engineering Education
2016   Best Paper: Military and Veterans Constituent Comm., American Soc of Engineering Education
2016   Outstanding New Assistant Professor, College of Engineering, Virginia Tech
2016   Outstanding Engineering Education Faculty Member, Department of Engineering Education, VT

C. Contributions to Science

I am PI for five NSF grants and co-PI for an additional NSF grant. These projects represent strong collaborations with partners at other universities, the Virginia Department of Education, the National Society of Black Engineers, and multiple Virginia Tech faculty inside and outside of Engineering Education. Research activities are summarized as follows:

Developing Diverse Problem-Solving Leaders

Analyzing data from my prior work jumpstarted my research team. One project focused on the organizational conditions and student experiences that foster the development of the "Engineers of 2020." I produced two reports with colleagues in Fall 2013 that were sent to every engineering dean in the country and served on a 2014 National Academy of Engineering Workshop panel to discuss how the project could impact policy and practice. I also produced journal articles and conference papers in the following areas since arriving to VT using those data: 1) the role of departmental contexts on faculty members’ teaching decisions; 2) influences on students’ leadership and interdisciplinary skills; 3) recruitment and retention of women and minority faculty and students; 4) differential effectiveness of learning environments for women and minorities.

Sample Publications:


Data Enlightened Practice along the Grade School-to-Grad School Pipeline

My funded projects extend along the time continuum in the preparation of engineers. Starting at the elementary school time point, I am collaborating with the National Society of Engineers (NSBE) and Purdue
University to study the impact of NSBE’s summer camps on underrepresented students and identify organizational enablers and inhibitors so that those kinds of experiences may scale up in a sustainable manner. Also within the K-12 context, another NSF project focuses on the high school-to-undergraduate point of the pipeline to understand variation in the educational system at the high school level. My other projects have applied similar methods across higher education segments of the pipeline. In collaboration with 4 Texas institutions, I have an NSF project focused on identifying the organizational conditions, policies, and practices that may best support transfer students in engineering. My team has also studied how existing VT institutional data can be leveraged to improve educational processes, academic trajectories, efficiency, and outcomes. Finally, I am collaborating on an NSF project focused at the end of the pipeline at the graduate student level to investigate students’ funding mechanisms and how those may differentially enable or inhibit access to experiences that influence outcomes.

Sample Publications:

D. Additional Information: Research Support and/or Scholastic Performance

**Selected Competitive grants**


- **Collaborative Research: Strengthening the STEM pipeline for elementary school African Americans, Hispanics, and girls by scaling up summer engineering experiences.** NSF, DRL-1614710. Year 1: $150,582 of a continuing grant, total anticipated: $645,775, 09/16-08/19. PI (50%). Co-I: Lee, W. Collaborative project with National Society of Black Engineers and Purdue University.

- **Collaborative research: Variation in the awarding and effectiveness of STEM graduate student funding across teaching and research assistantships, fellowships, and traineeships.** NSF, DGE-1535226. $749,211 (VT portion), 10/15-09/20. PI (100% for VT portion). Collaborative project with UT-Austin.

- **Gatekeepers to Broadening Participation in Engineering: Investigating variation across high schools comparing who could go versus who does go into engineering.** NSF, EEC-1647928. $503,093, 01/17-12/19. PI (30%). Co-I: Grohs, J., Matusovich, H., Bradburn, I.
NAME: Konstantinos Triantis

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Professor of Industrial Systems Engineering

EDUCATION/TRAINING (Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)

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<td>Columbia University, NY, NY</td>
<td>BS</td>
<td>05/1976</td>
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<td>Columbia University, NY, NY</td>
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<td>Industrial Engineering and Operations Research</td>
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<td>Columbia University, NY, NY</td>
<td>Ph.D.</td>
<td>12/1984</td>
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<td>MIT, Boston, MdeA</td>
<td>Executive Training</td>
<td>6/2000</td>
<td>Modeling for Organizational Learning through System Dynamics</td>
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A. Personal Statement

As co-director of SPL, Dr. Triantis has participated as a PI or co-PI has served in more than $6.6 million in funded research projects. Major sponsors include: NSF, NASA, ONR, DOE, DOD, American Red Cross, and USPS among others. Author of over 140 papers and reports and over 170 conference presentations and invited lectures. Over the years, the main thrust of Dr. Triantis research has been and continues to be the design of performance measurement systems for enterprise transformation and the use of the efficiency measurement paradigm for the design of engineered systems. More specifically, his most current focus is the establishment of theoretical foundations of systems engineering, the integration of the social and behavioral information/data in analytical performance measurement formalisms such as Data Envelopment Analysis, the inter-disciplinary integration of complex adaptive system frameworks for the understanding of dynamic behaviors and learning of socio-technical systems, understanding how complexity is learned by engineering students and professionals, and the design of critical interdependent infrastructure systems and processes. The research directions taken by Dr. Triantis are aligned with the following University destination areas and strategic growth areas: data analytics and decision science, intelligent infrastructure, global system science and policy formation and implementation.

Dr. Triantis established through departmental approval mechanisms, the extended campus ISE Ph.D. program in 2004. Prior to that, since 1983, he was instrumental in providing advising and guidance to a number of ISE students who completed their MS thesis and Master of Engineering, degrees. He also advised numerous students in our Systems Engineering program supervising MS Project and Reports but also being the academic advisor for our Master of Engineering Administration and MS in Systems Engineering degree programs.

Dr. Triantis has supervised seventeen Ph.D. students. One of his students won the VT outstanding dissertation award in science and engineering in 2003. With two of his students, they were awarded the Godeve
award in Operations Research from the UK Royal Operations Research society in 2008. Seven of his students currently hold academic positions, seven are with industry and three with government. Dr. Triantis remains in touch with all of his former Ph.D. students. To this day, he continues to work on research with eleven of them.

In addition to supervising Ph.D. students, Dr. Triantis has advised and supervised to completion sixteen MS thesis students, two Master of Engineering students, thirty MS project and report students in Systems Engineering, and four MS project and report Master of Engineering Administration students. He also served as the academic advisor of three hundred and forty three Master of Engineering students and seventy four MS in Systems Engineering students. The majority of his MS advisees work for industry or government.

B. Positions and Honors

Appointments

2000-present **Professor** of Industrial and Systems Engineering (ISE), Virginia Tech (VT), Northern Virginia Center (NVC), Falls Church, VA.

**Director** Ph.D. program in ISE (National Capital Region (NCR)).

**Co-Director**, System Performance Laboratory (1997-present) and System Dynamics Laboratory (2010-present).

2014-2016 **Senior Advisor**, Virginia Tech National Capital Region (NCR), Arlington, VA.

2005-present **Adjunct Professor**, Via Department of CEE, Virginia Tech.

2010-2014 **Program Director**, Civil Infrastructure Systems (CIS), CMMI, Engineering Directorate National Science Foundation, Arlington, VA.

2010 Visiting Professor, University of Liege, Belgium.

2010 **Visiting Professor**, Statistics Institute, Universite´ Catholique Louvain, Belgium.

2008-2010 **R.H. Bogle Faculty Fellow**, Virginia Tech, NVC, Falls Church, VA.

2003-2010 **Director**, Systems Engineering Program, Virginia Tech, NVC.

2003 **Visiting Scholar**, Athens Laboratory of Business Administration (ALBA).

1989-2000 **Associate Professor**, of ISE Virginia Tech, NVC, Falls Church, VA.


1983-1989 **Assistant Professor** of IEOR, Virginia Tech, NVC, Falls Church, VA.

1982-1983 **Preceptor**, Columbia University, School of Engineering/Applied Science, NYC.

1978-1980 **Instructor**, Rutgers, Graduate School of Management, Newark, NJ.

Editorial Board Membership

2008-2012 **Journal of Technology, Innovation, and Knowledge Management**

2012-present **International Journal of Data Envelopment Analysis** (senior editor)

2015-present **Service Science**

2015-present **Journal of Productivity Analysis**

Honors


2013 Elected the **John Lawrence Professor** of Industrial Engineering and Operations Research

2010-2014 Awarded, IPA, **National Science Foundation**, CMMI Program for the Civil Infrastructure Program.

2010 Awarded a **Virginia Tech research leave assignment** for the Spring Semester 2010.

2010 Invited Professor, **University of Liege**, Belgium, January-February 2010.

2010 Invited Professor, **Statistics Institute at the Universite´ Catholique de Louvain** April-May 2010.

2009 Received the College of Engineering Dean’s award for Excellence in Service.

2008 Received the Goodeve Best Paper Award from the Society of Operational Research, UK.

2008-2010 Elected as the **R.H. Bogle Faculty Fellow** of Industrial and Systems Engineering.

2007 Received a **Virginia Tech Supplemental Grants Award** to participate at the **Tenth European Conference on Productivity and Efficiency Analysis**, Lille, France, 2007.
2005 Received the Distinguished Service Award of the Virginia Tech/University of Virginia Northern Virginia Chapter of Phi Delta Kappa.

2005 Received a Virginia Tech Supplemental Grants Award to participate at the Ninth European Conference on Productivity and Efficiency Analysis, Brussels, Belgium, 2005.


2003 Granted the title and status of visiting scholar at the Athens Laboratory of Business Administration for the period April-June 2003.

2003 Invited to visit the Statistics Institute at the Universite´ Catholique de Louvain as a visiting scholar for the period March-April 2003.


2002 Received a Virginia Tech Supplemental Grants Award to participate at the Twentieth International Conference on System Dynamics, Palermo, Italy, August 2002.

2001 Received a Virginia Tech Supplemental Grants Award to participate at the Seventh European Workshop on Efficiency and Productivity Analysis, Oviedo, Spain, September, 2001.


1999 Received a Virginia Tech Supplemental Grants Award to participate at the sixth European Workshop for Efficiency and Productivity Analysis, October 29-31, 1999, Copenhagen Denmark.

1999 Received a Virginia Tech Supplemental Grants Award to participate at the Fifth International Conference of the Decision Sciences Institute (DSI), 4-7 July 1999, Athens, Greece.

1997 Received a Virginia Tech Supplemental Grants Award to participate at the EURO XV-INFORMS XXXIV Joint International Meeting, Barcelona, Spain, July 14-17, 1997.


1996 Invited to visit the Center of Operations Research and Econometrics at the Universite´ Catholique de Louvain during the first half of 1996.


1995 Received a Virginia Tech Supplemental Grants Award to participate at the Fourth European Workshop on Efficiency and Productivity Analysis, Center of Operations Research and Econometrics, Universite´ Catholique de Louvain, Louvain-La-Nu evue, Belgium, October 26-28, 1995.

1995 Received a VPI & SU Supplemental Grants Award to participate at the Fifth International Conference on Flexible Automation and Intelligent Manufacturing, Stuttgart, Germany.

1993 Received a VPI & SU Supplemental Grants Award to participate at the IFORS 93 XIII World Conference on Operations Research at the New University of Lisbon, Lisbon, Portugal.

1992 Received a VPI & SU Supplemental Grants Award to participate at the EURO XII/TIMS XXXI Joint International Conference at the Helsinki University of Technology, Helsinki, Finland.

1991 Received a VPI & SU Supplemental Grants Award to participate at the Second European Workshop on Efficiency and Productivity Measurement at the Center for Operations Research and Econometrics (CORE), Universite´ Catholique de Louvain, Louvain-La-Neuve, Belgium.

1986, 1987 NASA, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD. Summer fellow for the NASA/ASEE summer faculty fellowship program. Position awarded to conduct research in the area of query decomposition for heterogeneous distributed database management systems.

1987 Awarded a research fellowship by the Department of Navy/ASEE’s summer faculty fellowship program.
C. Contributions to Science

Papers Related to this Concept


Other Significant Papers


Significant Invited State of the Art or Review Papers and/or Presentations


D. Additional Information: Research Support and/or Scholastic Performance

2010-2014 NATIONAL SCIENCE FOUNDATION, ARLINGTON, VA.

Program Director, Civil Infrastructure Systems (CIS), Division of Civil, Mechanical, and Manufacturing Innovation (CMMI), Directorate of Engineering

Major Topics Supported:

Construction engineering that includes topics based on the application of information technology to construction operations, construction site safety, automation of construction processes, data modeling and visualization in construction operations, among others.

Infrastructure management that includes topics in life-cycle cost analysis, infrastructure resilience, infrastructure maintenance, network dynamics of civil engineering network systems, improvisational decisions and actions of construction workers, among others.

Transportation science and systems that includes transportation network modeling, transportation safety, intelligent transportation systems (ITS), traffic flow theory, traffic congestion mitigation, among others.

Lead of the Management Team for the Resilient Infrastructure Processes and Systems (RIPS) Solicitation (NSF 13-424):

This inter-disciplinary program (engineering, computer science, social/behavioral sciences) was focused on enhancing the understanding and design of interdependent critical infrastructure (ICIs) systems and processes that provide essential goods and services despite disruptions and failures from any cause, natural, technological, or malicious and to create the knowledge for innovation in ICIs.
Appendix II: Supporting Materials

1. Lake Urmia

Lake Urmia in north-western Iran was the largest lake in the Middle East and the sixth largest saltwater lake on earth. Unique ecological features of this UNESCO Biosphere Reserve had made Urmia the largest habitat of brine shrimp. The Lake is the home of various species of Archaeabacteria and Bacteria, Microfungi, Phytoplankton, and 311 species of Plants. It also hosts 226 kinds of Birds. The lake is also known for its hundreds of small islands serving as stopover points during the migrations of several wild birds to and from Russia. The town Urmia, on the west side of the lake, has a population of 700,000 people.

Several reports show that the lake suffers from serious ecological problems, and many of the indictors are easily observable from the lake itself. Between 1972 and 2014, the area of the lake shrank by 88%. The evaporation of the water has exposed the lakebed and caused windblown salt which may lead to environmental health crises, including increase in infant mortality, cancer, and liver, kidney, and respiratory diseases. This phenomenon is similar to what happened after the death of the Aral Sea. In addition, it will increase unemployment by reducing tourism and shrinking the fertility of the land in the region.

Fortunately, the public awareness about the lake has increased and huge outcries urged the government to take action. Government officials promised to spend $5 million to save the lake in a period of 10 years. Officials attribute the lake’s desiccation to the drought in recent years while critics point to mismanagement of water resources and construction of a raised road across the lake. The population of the region more than tripled during the past forty years. Multiple dam construction and pipe transfer projects have made water available for domestic and agricultural purposes. In 1999, a project was completed to pump water from the Zarineh River (one of the main feeders of the lake) to the largest city of the area. In addition, forests have been transferred to agricultural lands to fulfill the needs of the growing population. Specifically, forest cover of Zagros Mountain has declined. Forests of Zagros maintain naturally controlled water flow to rivers feeding the lake. As the lake shrinks, the climate of the region becomes drier and more water is needed for agriculture.

In 2011, multiple demonstrations took place in close cities demanding that the government take immediate actions to protect Urmia Lake. Not all demonstration ended peacefully. The slogan “let me cry to fill the lake”, a highly chanted motto depicted the emotional reaction of the region. According to official state reports at least 70 supporters of the lake were arrested. Several proposals were discussed including channeling water from other rivers to the lake, destroying several dams, or funding relocation of people living around the Lake. In order to find solutions for saving the lake, policy makers need to know what caused the lake to shrink by 88% in 44 years. The lake is just an example of many similar environmental challenges that humans are dealing with especially in less developed areas.

Questions
1. What do you think “went wrong?” in Lake Urmia? Based on the provided text, and your own thoughts, provide a short explanation less than 20 sentences, on why Urmia is suffering from its problems.

Given the problem, what should be done to protect the environment and ecosystem of Lake Urmia?
2. The Systems Thinking for Engaging Problem Solvers

The Systems Thinking for Engaging Problem Solvers (STEPS) tool includes a problem scenario with prompts to elicit responses aligned with the Dimensions of Systems Thinking framework (DSTF) as well as a scoring rubric. The DSTF framework and vignette are shared below.

**Village of Abeesee Scenario**

The Village of Abeesee has about 50,000 people. Its harsh winters and remote location make heating a living space very expensive. The rising price of fossil fuels has been reflected in the heating expenses of Abeesee residents. In fact, many residents are unable to afford heat for the entire winter (5 months). A University of Abeesee study shows that 38% of village residents have gone without heat for at least 30 winter days in the last 24 months. Last year, 27 Abeesee deaths were attributed to unheated homes. Most died from hypothermia/exposure (21), and the remainder died in fires or from carbon monoxide poisoning that resulted from improper use of alternative heat sources (e.g., burning trash in an unventilated space).

**Processing Phase**

1. Given what you know from the scenario, please write a statement describing your perception of the problems and/or issues facing Abeesee.
2. What additional information do you need before you could begin to develop a response in Abeesee? Consider both detail and context of the problems/issues you identified.
3. What groups or stakeholders would you involve in planning a response to the problems/issues in Abeesee?
4. Please briefly describe the process you would use planning a response to the problems/issues in Abeesee?
5. What would you expect a successful plan to accomplish?

**Response Phase**

1. Given what you know and a budget of $50,000, develop a plan that would address the Abeesee situation maximizing the impact of your $50,000. Use a numbered, step-by-step guide, recipe-style to explain your response plan. For example: Step 1: Buy the noodles. Step 2: Boil water. Step 3: Add the noodles. Step 4: Drain the noodles.
2. On the previous page, you developed a plan. Without specifically changing your plan, reflect on it. What challenges do you see to implementing your plan? What are the limitations of your approach?
3. References


Appendix III: A provisional job ad

The Center for Educating Systems Thinkers (CEST) at Virginia Tech invites applications for five positions aligned with the Global Systems Science Destination Area (GSS DA). GSS DA focuses on critical problems that cross the nexus of natural and human systems. GSS DA integrates three areas including bio-geophysical sciences, the sociocultural realm, and technology and tools. The CEST conducts research on cognitive barriers that impede the understanding of the structure and behavior of complex coupled systems and it develops methods that can assist in improving the cognitive skills of students and working professionals so that they can better understand system complexity. In addition, the CEST assists in curriculum development and prepares students to identify and solve 21st complex problems. Moreover, CEST provides assessment tools for evaluating courses within the destination areas. Three of the openings are for faculty positions at open rank of Assistant, Associate, or Full Professor with expertise in (1) Cognitive Neuroscientist to expand the CEST research in investigating cognitive barriers to complex systems thinking through neuroimaging research (e.g., functional near-infrared spectroscopy (fNIRS), functional magnetic resonance imagining (fMRI)), (2) Behavioral Economist to teach the most recent findings on psychological, social, and emotional factors that impact the economic decisions of the end-users of a complex system and to expand the theories of behavioral economics for global coupled systems, and (3) Philosopher/Historian of Systems Science to evolve the theories of systems science. The fourth position is for a Professor of Practice with significant industry, governmental, or non-profit sector experience who could actively teach across the courses identified earlier in the proposal. Finally, the fifth opening seeks an A/P Faculty Director of the Center for Educating Systems Thinkers who would facilitate interdisciplinary research, curricular design and implementation, and who would help the team navigate extramural funding opportunities across the diverse settings.