**External Review Report on the PSU System Science Program**
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# Summary

PSU was a pioneer in the “system science” field. Forty years after the ideas began to be developed, the field, now variously referred to as “Complex Systems Science”, “Complexity Science”, and, simply, “Complexity” is poised to help define research in many fields over the next decade. This is especially true in areas such as climate science, environmental science, urban studies, energy, transportation, education, human systems, public health, socioeconomic systems, management, finance, national security, and, of course, engineering. In all these areas the systems being studied and designed are increasingly complex, and are outstripping the analytical capacity of standard techniques. Complex systems methods - based on concepts such as self-organization, emergence, nonlinear dynamics, fat-tailed distributions, agent-based modeling, and complex networks – are critical for progress in this situation. This is clear from the remarkable interest in complex systems ideas even in the popular press, driven by the challenges of financial crises, terrorism, climate change, and global demographic upheaval. PSU has a valuable opportunity to build on its historical position as a pioneer and define itself as a leader in this field. Indeed, this opportunity is amplified by PSU's other existing strengths in areas such as computer science (especially machine learning), policy research, human systems, and – recently – public health.

Obviously, PSU leadership faces the decision of how to allocate resources associated with the program going forward. The review team understands that many universities face difficult budget constraints and the idea of reallocating faculty lines and resources to disciplines with higher potential for generating resources is appealing. However, in such a decision, there is the question of competition with other universities. As such, the review team felt that careful consideration of the mission of PSU and how the System Science Program may help distinguish PSU from its competitors is a critical aspect of decisions regarding the program going forward. The System Science program's accomplishments are astounding given the resources now devoted to it. There is very strong faculty and student support for the program and its contributions to intellectual life at PSU. Careful nurturing of the program can distinguish PSU as a regional leader in complex systems science and has the potential to generate a number of collaborative, interdisciplinary research activities. This research could bring in significant resources as NSF, NIH and many foundations have included complex systems in their RFPS, and educational standards organizations have emphasized systems thinking in new standards documents. In the remainder of the report, we outline the challenges the program faces and options for nurturing it going forward.

# Challenges and Opportunities

The Systems Science Program provided the review team with a comprehensive self-study report laying out in detail the current situation of the program, including the challenges it faces, and the opportunities it represents. On balance, the review team felt that the opportunities afforded by the program are significant and challenges facing the program are manageable by an administration committed to leveraging the System Sciences program as part of its mission and as a way to distinguish the university from its peers. We see very high potential, for example, to the engage with the local Portland community in a number of ways through collaborative research focused on solving important problems around energy, public health, health care administration, and urban development that all represent complex systems science challenges.

## Challenges

Based on the self-study report, it is clear that the program is at a critical point, and faces three acute problems:

1. **Lack of Faculty:** It is remarkable that a program of such scope, utility and vitality is currently staffed by only two full-time faculty members. From the data presented in the self-study report, it is clear that these two faculty members are providing service far beyond what is expected in any normal program at comparable universities. The program has maintained an enrollment of about 30-40 graduate students in recent years, which represents a huge, unnatural advising load for the faculty. In addition to this, they are teaching a large number of classes that, judging from enrollment statistics, are clearly of value to students in many other PSU programs. Recently, the program has also ventured into undergraduate education with the development of a minor. This will further exacerbate the already unsustainable load that the faculty and graduate assistants are carrying.
2. **Lack of Administrative Support:** The Systems Science program currently has one half-time administrative staff member serving all its needs. This is absurdly small for a program of even its current size, and even more so for the kind of program it should be. As a result, a lot of the administrative load is also being carried by the faculty members who are already overloaded with academic work.
3. **Lack of Student Funding:** A large fraction of graduate students within the Systems Science program are unfunded, reflecting the relatively limited amount of external funding available. However, this is not surprising given the fact that the program has only two faculty members who are overloaded with academic and administrative work. A larger faculty with lower load would have a better chance of getting significant external funding. A significant fraction of the student body consists of part-time students, which may be one reason why the program is able to carry such a large student load with its limited funding resources. However, most of the gap is being made up through volunteer service by extremely committed students and faculty.

In addition to these issues identified in the report, the review team believes that the Systems Sciences Program also faces some other difficulties, including the following:

1. **Lack of Visibility:** The team felt that, while the Systems Science Program is considered very useful by specific faculty and programs across the University, its visibility is lower than is warranted by its significance. Some of this may simply be a consequence of its interdisciplinary nature, but much of it can probably be ascribed to its small faculty size and being housed in an out-of-the-way location.
2. **Unevenness of Institutional Support:** The team felt that, while individual faculty recognize the value of the Systems Science Program, the institutional support is quite uneven - both across administrators and over time. This is reflected in the decision not to fill vacated faculty lines and to provide very little administrative support. Broad and sustained institutional support is absolutely key to the sustainability of an interdisciplinary program if it is not to suffer a "tragedy of the commons" situation. The University needs to make an institutional decision about the value of the program, and follow a clear, sustained policy based on that decision.

## Opportunities

In our meetings with faculty and students, it became clear that there is strong support and appreciation for the program that can be leveraged to build a strong program and take advantage of a number of opportunities. We first summarize the views of faculty and students, and then outline some opportunities we see.

**Faculty/Administration Views**

The review team met with a range of faculty who have had significant interactions with the systems science program. This included Darrell Brown from the school of business administration; John Reuter, chair of Environmental Science and Management, Heejun Chang, chair of the geography department; Marek Perkowski , faculty member in Electrical and Computer Engineering; Melanie Mitchell, faculty member Computer Science; Tim Anderson, chair of Engineering and Technology Management; Neal Wallace, Professor of Public Administration; Marek Elzanowski, Steve Bleiler and John Caughman, professors in the department of Mathematics; and Alan Yeakley, chair of the School of the Environment . Overall, there was very positive sentiment towards the program. That sentiment took distinct forms among the faculty we spoke with. One view that was shared across all the faculty was an appreciation of the historical role Systems Science has played at PSU. Many of the current doctoral programs, such as psychology, mathematics, environmental science had their origins in systems science, with the disciplinary doctoral programs emerging from systems science PhD specializations. Now that these disciplinary doctoral programs exist on their own, the faculty had different views on what that should mean for their interactions with systems science. Most of the faculty we spoke with saw continuing benefits of strong interactions with systems science. Others, while acknowledging the importance of systems science in their origins, had strong priorities for improving and expanding their own faculties, and consequently had less interest in collaborations with systems science. Almost all of the faculty we spoke with saw a continuing value for systems science in terms of PSU's mission. But they had different assessments of how well that promise is currently realized, with some

faculty seeing concrete benefits accruing, and others somewhat frustrated that the potential benefits were not resulting in concrete help to their programs. Of these latter faculty, almost all attributed the lack of concrete benefits to the small size of the systems science faculty, mentioning that when the faculty was larger, they had a greater diversity of research projects and interests that could be spread more widely in the university. All faculty we spoke with expressed the view that, given the small number of faculty in systems science, there has been a very high level of service and productivity. In addition to the departments we met with, we heard about significant interactions with the departments of psychology, philosophy and chemistry.

**Student views**

The graduate students in the systems science program expressed very strong appreciation for the program. They saw it as occupying a unique niche in the national landscape and were drawn to it from a wide variety of geographic locations and academic contexts. They expressed strong support for the specific types of problem solving skills and "way of thinking" that they saw as distinguishing them from their peers in other discipline-based programs. This view seems to transcend particular career trajectories, articulated both by students who work in government or industry and those who are more inclined toward academia. Finally, several students with non-traditional backgrounds and life trajectories expressed deep appreciation for the fact that the System Science Program provides a home for them to develop intellectually like no other program could.

Based on our discussions with faculty and students along with our knowledge of the fields of complex systems science, network science, and data analytics, we see a number of opportunities:

1. The Program can become a hub of interdisciplinary research for funded projects supported by grants from NSF, NIH, DoE, DARPA, etc. Increasingly, such grants require cross-disciplinary participation, and an active Systems Science Program could be a facilitator for this.
2. The Program could provide a set of core capabilities in complex systems analytics and modeling that would be accessible to researchers in all other programs at PSU and beyond.
3. The Program could provide a sort of complexity science "extension service" – engaging with the community to help address real-world problems that require complex systems methods. Examples of such problems include the development of sustainable urban environments, optimization of human and energy resources, addressing the effects of climate change, etc.
4. By emphasizing and promoting its interdisciplinary nature, the Program could become an international magnet for exceptionally committed students seeking to work on large interdisciplinary problems. If managed well and given resources, this could become a national – and even international center of excellence for complex systems, and increase the University's international visibility.

See the Appendix for comments from individual students.

## Recommendations

The review team believes that the future course of action regarding the Systems Science program should be based on a clear vision for PSU and the Program's place within this vision. Over the coming years, the science of complex systems is going to be a fundamental component of many disciplines, including environmental and climate science, urban systems, public health, biomedical sciences, economics, sociology, psychology, computer science, engineering, etc. Many of these disciplines are central to PSU's research, educational and service mission, and its valuation of the Systems Science program should take this into account.

The review team feels that the current name of the program - Systems Science - is rather dated. A new name should be chosen that highlights themes such as "complexity, "networks", "modeling" and "analytics". These terms reflect more accurately not only the work that occurs in the program now, but - more importantly - what should occur in it. To the extent that some of these areas are not fully represented in the current setup, they should be augmented through new faculty hiring. This is especially true of the networks area, which is important for a program such as this.

The name chosen would depend critically on the the overall vision and mission of the university over the long term. It should 1) be reflective of the cutting edge of the field and 2) be consistent with how the program articulates with the mission of PSU. The review team saw at least two important considerations:

1. The stated mission of PSU is to serve the urban population of Portland. There are many synergies between the System Science program and this mission. Complex systems: transportation, energy, health care, public health.

2. Leveraging place: Portland, and Oregon more broadly, face a number of challenges for which System Science is exceptionally important: non-linear environmental dynamics associated with global change, disaster and risk management,

The review team sees three possible approaches to improve the current situation, ranging from a minimal solution that will provide a short-term "rescue" to a longer-term one requiring additional investment of resources. Of these, the review team would strongly urge pursuing the latter option, which is Option 3 in the list below. While the review team understands the significance of short-term resource constraints, we feel that the program is too important to be evaluated purely at this level, and even if a short-term option is chosen now, it should be followed soon with a more ambitious longer-term plan.

The possible options are:

1) **Minimal Investment Option**. This option is motivated by the Review Team's assessment of the requests outlined in the self study document of adding one fixed term faculty and some administrative support. This

option does not seriously address the need for an appropriate home for the System Science Program. Rather, it simply focuses on the demographics of existing faculty who face retirement soon. In this model, the System Science Program, which presently adds value to the university well beyond that typical for a unit with a comparable resource base, would continue under its present model. This is clearly not sustainable as its success depends on the outsized efforts of current faculty. The Review Team does not recommend this option, except as needed for a short term bridge. Rather, we present it simply as a baseline to which other options can be compared.

2) **Medium Investment Option: Absorption/Dilution**. In various conversations with PSU faculty and administrators, the Review Team sensed a marked preference for the notion that the Systems Science Program must be housed in another academic unit. While the review team recognizes obvious practical administrative factors supporting this view, we see a number of concerns associated with this option. The two most salient are 1) The flexibility of the System Science Program to engage in a wide range of activities and make contributions across PSU may be diminished if sequestered in another academic unit, and 2) inevitably, due to the very administrative practicalities that membership in another unit might help address, the System Science Program will be forced to serve the interests of the host department and become diluted.

3) **Higher Investment Option: Small, autonomous, integrative unit**. In this model, the System Science Program, however renamed, exists as an independent unit outside of any college, school, or department. It serves a pan-university function of providing expertise to enrich graduate and undergraduate training in complex systems, network science, and data analytics, as it does now. The unit consists of 4 core, full time, tenure-track faculty. Creative appointments are used to synergistically meet knowledge domain specific needs in other units, but new hires emphasize faculty with some complex systems science expertise. Such “external affiliated faculty” are expected to contribute some portion of their time to the System Science Program to engage in collaborative research, teach and mentor at the graduate level, and contribute to undergraduate teaching as appropriate. These external faculty would span key relevant disciplines and devote perhaps 20% of their time to System Science Program Activities.

# Appendix

## Individual student views

**Erin Kenzie:**

There is a lot of goodwill from students toward the program, but these challenges force students to keep a narrow focus on completing their studies and constrain potential collaborative and creative work (which would in turn strengthen the program). Students also expressed an interest in the curriculum being updated/expanded and for existing relationships with other departments and the community to be strengthened while maintaining our own autonomy and identity. It's my impression that many students would be excited about the 'extension service' idea -- many of us have talked about something similar before.

It is also my impression that one of the main things holding Systems Science back has been poor communication or understanding of who we are and what we do (or what we're capable of doing) on the part of university administration. PSU has a strong focus on serving the community, interdisciplinarity, and sustainability -- all areas where systems/complexity science is a great fit. And there seems to be a lot of support from outside students, faculty, and community partners who actually do get to know us. With the right resources and planning, I think the program could be expanded into a more robust version that plays a more visible and leading role in the PSU/Portland community.

**Alexandra Nielsen:**

Systems science has opened professional doors for me. Details about my work appear in the self study document.

Because I bring interesting methods to these teams, success breeds success. My policy work is getting attention and collaborators are seeking me out. None of this would be possible without systems science. Grant funded work brought publications, collaborations facilitated through Wayne and other members of my dissertation committee brought consulting opportunities and exposure to other professionals through conferences.

The downside of all this opportunity is distraction. Many of us have to scramble for little bits of money here and there. When people contact Wayne with opportunities, he often offers them to me personally because he knows I'm skilled and professional, and also because I need it to support my family. Some of us teach classes that we design ourselves. We provide huge amounts of student support for very little pay. The dissertation is always the thing to give. We are not supported well enough to have a "shop" model for research. There is freedom and opportunity in designing one's own research (and course offerings) cut from whole cloth, but lack of real, long term funding streams means that a lot of us are on the "long path" to PhDs. It's going to take me more than 6 years--others closer to 8 or 10.

There is community in systems science. We are friends and colleagues in the truest

sense. We turn to each other for methodological support, to explore our own ideas and to learn about others' ideas. This is rare on this campus--which is more professionally oriented. I love systems science and I want more people to have what I have. We need investment to grow, and we need growth to survive and thrive. Many of us have been fighting so long firefighting to keep our home alive. There seems to be a new threat every couple of years. New dean, new chair, new person in university leadership at any level and we have to expend energy proving "what have you done for us lately," again and again and again. Struggle is exhausting. We have passion for this work and these ideas and this family.

Thanks for taking the time to review our program. We love it here.

**Cecily Froemke:**

I am a graduate of the Systems Science MS program and am currently a doctoral candidate in Systems Science. My research focuses on the role of information theoretic Reconstructability Analysis.

(RA) applied to large healthcare data sets, primarily with a focus on prediction of healthcare outcomes. RA has the potential to predict better than traditional statistical methods such as logistic regression, and therefore would offer great value as healthcare systems seek to utilize predictive analytics to improve outcomes and reduce costs.

I have worked for over a decade in healthcare and nearly 2 with data and analytics. I work at Providence Health & Services, now the largest health system on the west coast. I lead a team of analysts, data architects, and project managers in support of our Enterprise wide service line strategies to improve the health of the community we serve at a better cost to the consumer and payer. In order to achieve this, we utilize data as the key factor to understand what variation we have in services and outcomes and where we have opportunity to improve on both fronts.

Certainly there is a need to have information workers who can handle increasingly large and complex data sets. This ‘big data’ is one of our enterprise assets, and it is getting bigger every day. Unlocking the power of big data requires a skill set that we need more of – as skill that individuals with a systems science background are generally equipped with. However, the issues we face in healthcare today are also organizational and not necessarily technical. Our data workers of the future will have to understand how all of our information systems come together and how this data can be structured in a way that best supports our organizations strategic objectives.

Organizations are extremely complex in their own rights, and the systems approach I have by training has provided me the ability to not only navigate the existing organizational structure, but design and optimize organizational structures that can adequately handle the complexity, both technical and non-technical.

In a growing health system, with enterprise home bases in both Seattle and Portland, the possibilities that would emerge from a strengthened connection between Providence and Systems Science seem endless. We are headed into a future rich with heaps of information embedded in complex organizations. Systems practitioners are equipped with an absolutely novel tool kit to understand and solve some of the most complex problems we are facing in the healthcare industry today.

**Diana Fisher:**

I wanted to pursue a PhD in System Dynamics with emphasis on its use in pre-college

mathematics. The program at PSU in System Science seemed to fit my goals: review the literature on the use of System Dynamics modeling as well as the literature on the use of modeling with technology in mathematics at the pre-college level; learn to write research papers that may be worthy of publication in mathematics education research journals; execute a formal classroom experiment on the use of System Dynamics modeling in algebra II at the secondary school level. Dr. Wakeland allowed me to design a program path that would allow me to pursue my goals. I found his guidance and support invaluable. The environment within the program was/is very positive, open, collegial, and respectful of students with different interests and personal backgrounds. I was exposed to students who thought

differently from those in the discipline within which I had previously studied (theoretical mathematics). I found that experience exhilarating. I could not have hoped for a better educational experience. The program sets a high bar, but one that was both enriching and supportive.

We, in System Science, have much to offer other departments. Some of us have helped other departments by teaching courses they needed/wanted but using a different perspective from the traditional approach. Sci 313U: Environmental Mathematics Modeling, is a case in point. This course was offered in the Environmental Science and Management department using a traditional calculus approach, in the past. The course died. It was resurrected but transformed using the System Dynamics modeling approach. Undergraduate students have given very positive feedback within the systems courses they have had the opportunity to take at PSU. Moreover, some of us (System Science graduate students) have helped other graduate students at PSU who needed/wanted models built to support their research work. I know of no other universities in the region that offer a System Science program of the type that we have at PSU. It could be a major draw for students to this university (if the program were enhanced). System Science has designed many of its modeling courses with a hybrid structure, so they can be taken online. This allows students who still work full time, but who do not live within reasonable commuting distance of PSU an opportunity to take high level classes at PSU.

**Peter Geissert:**

My name is Peter Geissert, and I am a student in the PSU Systems Science PhD program. I am currently engaged in preparing my dissertation proposal. My background is in Public Health and social services, in particular addiction, homeless and mental health services. While working towards my MPH I became interested in epidemiology and quantitative methods. It also became increasingly obvious to me that there were limitations to linear estimation methods for application to social processes. I was introduced to System Dynamics modeling by Amanuel Zimam, a student in the program who took many of the core public health classes with me. I knew that complex systems, and particularly computational models, were what I was missing. This intuition that Systems Science is a fruitful avenue for a researcher in my field has been validated time and again. Perhaps the best example is that the Academy Health Annual Research Meeting has now created a Systems Science scholarship program to draw researchers.

When I finished my MPH I was working under a 4 year NIH grant, and I had the opportunity to stay on for a PhD with financial support. It is this out of department support that has allowed me the freedom to stay on and pursue my degree in Systems Science. I know that there are many other people who do not have the same level of support. While it is great to have a room full of the hard core people who are not deterred by the lack of support in department, I also feel a sense of mission to outreach to many disciplines and domains. I would like to see the department have the resources

to support a larger student base. I strongly suspect that the returns on investment are potentially huge, if sometimes indirect.

When I arrived at Systems Science I found an environment full of people from a broad range of backgrounds and disciplines. In one conversation you might get feedback on your idea from people in many different fields. What struck though was not just the diversity, but people's level of interest and willingness to discuss other people's problems and ideas. I feel like this environment has enriched my learning immensely.

My interests are many and varied, including epidemiology, data science, machine learning, generalized evolution, and complexity economics, but much of my work these days centers around health and health care. I am currently working on wrapping up work on an evaluation project of Coordinated Care Organizations, Oregon's equivalent of Accountable Care Organizations, with Professor Neal Wallace in the Public Administration Department and John McConnell at OHSU. I am also working on an extension to the evaluation of the Oregon Prescription Drug Monitoring Program with Professor Wakeland, and a research team from Acumentra Health and OHSU. I am also working on a homeless Respiratory Health study with Professor Alexis Dinno from the School of Community Health. These projects use a variety of mostly statistical methods. I think it is important to stress that Systems Science as not just a collection of methods. Complexity is a lens that brings generative processes into focus. This is an outlook that I bring to my work whether I am running a regression or building an agent based model.

I have chosen to focus my dissertation on causality in dynamic systems. I hope to explore whether use of statistical and simulation methods in tandem can provide a formal method for recovering cyclic causal structures. There is no other department on campus where I could write this dissertation, and yet I could apply it anywhere. That is what Systems Science means to me.

**Nick Turman-Bryant:**

As a first year PhD student in systems science, I have benefited from the interdisciplinary home that the systems science department has provided for my multifaceted interests. My first love is energy access, and I'm keenly aware that energy--like many of the world's most pressing questions--does not fit neatly or discretely in any particular department or discipline. Now that my interests are broadening to embrace development technologies more generally, I'm grateful that systems science has been willing to provide a disciplinary platform from which to launch my research in development engineering. Although my research is conducted through the Sustainable Water, Energy, and Environmental Technologies Lab (SWEET Lab) and I am taking a variety of courses related to ecosystem services through the IGERT Fellowship, Systems Science is providing solid training and grounding in computer simulation and theory as I pursue these interdisciplinary interests.

I am very new to systems science, but my impression is that the world is waking up to the importance of complexity science as a lens through which most problems are more appropriately viewed. As it relates to my research, complexity science applied to development theory is one of the cutting edges of research. This includes not only critiques of traditional international aid paradigms (and the lack of intrinsic feedback loops), but also in the simulation of impacts from development interventions through agent-based or system dynamics models.

Regarding System Science's contribution to PSU, it seems that the systems science department is undergoing a painful metamorphosis from a graduate clearing house for a wide variety of PhD programs to providing service courses in simulation, modeling, and

complexity theory to a university that under-appreciates (or in some cases duplicates) its offerings. With the right investment and organization, I believe the systems science department (if that's even the right word) could improve efficiencies within the university by offering transdisciplinary coursework in complex adaptive systems and computer simulation and modeling.

**Trevor Thiess:**

I was drawn to Portland by the Systems Science program. Feeling like my engineering education had given me lots of tools to use, but limited perspective, I was seeking a program that would encourage development of my diverse interests and challenge me with new problems. I learned about systems theory in undergraduate and immediately set out to learn more and find graduate programs. As I got more into the subject I was really gripped by the mid-20th century systems philosophy writing, but I was discouraged seeing that that sort of work is very sparse these days. I did, however, find Martin Zwick, who is actively publishing in the area, so I read several of his papers and gave him a call. He was extremely nice and talked to me for an hour and a half, we exchanged a few papers we found intriguing, and he encouraged me to apply to the program.

It was unfortunate to hear that he wouldn't be able to take me on as a graduate student because his career plans are so uncertain these days, but I was just excited that I had found a program that fit what I wanted so beautifully. About to finish my first year of my work towards my PhD here, I couldn't be happier that I have chosen this program rather than one of the more standard PhD paths my friends are on. The freedom, the breadth of content, the passion of the program, and the history of the subject are all inspiring to me and without that I wouldn't be able to explore my interests in the way I've been yearning to and I would likely just end up feeling frustrated again like I had at the end of engineering school.

I'm eager to help this program grow again to be able to accommodate new subject matter, attract more competitive students, and contribute more to the systems community. I love this program and I'm willing to put a lot on the line for it, but in order to make this program sustainable over more than just the next couple of years the work of us in the program needs to be met with efforts from the encompassing organizational structure to support us and facilitate our growth. Systems Science strikes me as such a unique opportunity for this university to pull in high-caliber interesting, passionate students, I hope they find a way to hold onto it. I certainly wouldn't be at PSU if it wasn't for this program and I hope that I'll be able to enjoy the rest of my doctoral education in this program.

Thank you so much for your time and work, I'm eager to see how we can move forward.

**Robert Kramer:**

A product of the optimism of the 90's, I was told I could accomplish anything. The delusion of personal exceptionalism and an overdeveloped sense of self importance could only take me so far. Over the last few years, I have actually tried to realize my ideas instead of simply feeding off the fantasy of their impending success. Before being accepted, I attempted to use makerspaces and MOOC's as an alternative to graduate school. On my own, I found it exceedingly difficult to apply anything I've learned in the past to new ideas. I've lacked the influence to create my own social organizations. I found myself wishing I had the support of others interested in the same material and the structure of an institution for guidance and legitimacy. Before I was given the opportunity to participate in the Systems Science graduate program I felt absurd when I tried to explain what I did with my time. Systems Science gives me new tools for exploring my

ideas, some feedback as to which ideas are worth exploring, and the ability to work with a team of colleagues to contribute to the world around me.

Eight years ago I graduated from the Georgia Institute of Technology with a B.S. in Aerospace Engineering. I recall spending several lectures linearizing the Navier Stokes equations for fluid dynamics. I was struck by the number of and ease with which we made assumptions. I realized the entirety of what I had learned to that point was built on similar assumptions. I wondered when I would learn about how all these things interacted with each other. I wasn't going to. It wasn't known. I couldn't believe every problem in my curriculum was essentially solved the same way. Take the real problem and simplify it until you can break it up into individual pieces. Isolate each piece and solve. Add it back together. Our understanding seemed so incomplete. I felt like there had to be a better way to deal with these interconnected parts than the stumble in the dark and hope method we employed. I also struggled at times during my undergraduate experience. I found I may not be a great "fit" in a traditional engineering path.

Over the next few years, I completed a SCUBA Divemaster Internship, travelled through some ten odd countries, taught English in South Korea, and worked as the lead instructor at a Mathnasium Franchise. It was during this time, I began to think of humanity's major problems as not being technological in nature. Our most basic problems seemed to be based in how humans organize and interact. Poverty, Exploitation, and the seeming intractability of the problem cannot be ignored when traveling through the developing world. Paradoxically, the happiness and joy a strong cultural sense of community provides also cannot be ignored. My travelling experience was a solipsistic journey of childish extravagance, but it fundamentally changed the way I see the world and the people who live in it.

As I grow older and attempt to become useful to the world around me, I'm unsure of the professional path I will take. I know I'm interested in questions like: How do systems process information? Under what conditions does emergent behavior occur? What is the simplest metric which will indicate the region of dynamics the system is currently in? How can human beings apply this information to our institutions and processes to live more harmoniously? Under what conditions are humans the most likely to lead meaningful lives? I still love space and fast machines. I'm generally fascinated by the overall behavior of just about everything. I would like to help more people satisfy their individual curiosity by studying educational systems and working toward organizational structures that naturally lead to emergent learning. I don't know of any other program in the world where I would be given the freedom and support to explore these interest. More importantly, without the Systems Science department I would still be lost. I wouldn't have the ability to turn my passions into useful tools for society.

I am incredibly grateful for the opportunity I have been given. I've done well since being admitted. In addition to Systems Philosophy and the core modeling curriculum, I've been able to build analytic and machine learning skills outside of the program. I was given support for an idea for a Systems Science student organization. We recently formed syscNODE and presented an initial prototype of an affective social robot at the student research symposium. I was also given the opportunity to experiment with a self-organized educational idea I've had for a while called FlyingU. We met regularly and spent a term using online resources to study Networks / Graph Theory together. I would like more core Systems Science coursework; especially around dynamical systems and neural nets, but I understand the extremely limited faculty is spread too thin. The only truly disappointing part of my short time here at PSU is the lack of institutional support for the program that has given professional meaning to my life. An institution should be judged by its actions, not its rhetoric. I see fearless posters all over campus, but the only actions I've seen indicate a complete surrender to the fear of economic loss.

Given more support, Systems Science could increase productivity across disciplines. We have skills that can benefit the greater academic environment. We have tools to deal with almost any problem and exposure to ideas across disciplines. The department could be a hub between departments that rarely speak. There are profound discoveries at the intersections of disciplines like biology and computer science. Many of the truly great scientific discoveries are found when these “separate” disciplines work together. Systems Science is willing and able to provide these links. The Systems Science department is a tremendous asset to the greater Portland State academic environment; truly greater than the sum of its parts.

**Shawn Chandler:**

My Systems Science education allows me to compete with and lead a group of top notch global management consultants. At Navigant, more than 75% of my peers in the firm (more than 300 people out of 400) have advanced degrees from MIT, Stanford, Caltech, and other top name-brand technical schools. Although I have been with the company only one year, my capabilities (I believe as a direct result of my education) in system science have led to me being chosen to lead our practice area for Grid Modernization – Systems in the firm, ahead of many others with a similar education. In my opinion, PSU’s faculty competes with the very best institutions in the world in terms of the quality of education in system science.

Regularly and successfully contribute to client engagements with the largest companies in the world meeting stringent expectations for excellence, conduct internal development and industry systems discussions with highly successful academics and business professionals, and (as a direct result of my experience from PSU), am able to compete with them directly in both modeling and systems thinking, and contribute to industry matters with the technical aptitude expected from a global leader. As a Chair of a technical committee for IEEE, I regularly am asked to speak at industry events and conferences, and give my thoughts on system interests as they pertain to development of the smart grid. My education has given me significant capability in this area, and I generally utilize material from topics including but not limited to discrete multivariate modeling and information theory, system architecture and design principles, game theory, agent based modeling and simulation, and system dynamics.

The world is becoming a more complex place, with new systems being interconnected every day. Intel predicts there will be more than 20 interconnected devices per person in the world by 2020, an astounding figure if the prediction holds true. Each and every one of these devices will be streaming or utilizing data, and optimization of interaction between these devices and the grid is a primary concern within the energy industry. Proper planning, architecture and design, and implementation of these systems requires special skills. System science lays the groundwork and in fact the detail required to contribute to this evolution of the Internet of Things.

**Foster Gough**:

I approached Systems Science on both a graduate and undergraduate level in modeling and simulation. My background as an Economics student was largely Neoclassical theory and public + environmental applications. By learning the modeling process in Systems, I learned the sort of thinking and computations that went behind the subject matter of my core classes; such topics and inner workings that were often smoothed out of the undergraduate Econ curriculum. The Systems curriculum also introduced me to heterodox economics and questions on what happens outside of equilibrium, which my Economics curriculum certainly did not cover. I was further introduced to ideas related to Ecology, which bridged scientific and social concepts that informed my continued

education in Environmental Economics.

The study of scientific inquiry in Systems is what developed my philosophy for understanding concepts in the Social Sciences and filled many holes in my framework of understanding social phenomena as well as mathematical structure. Because of my philosophical development, research opportunities with my favored faculty were opened up to me in both Systems and Economics. As a direct result, I am able to approach the work of my professors and develop more meaningful research framework in my projects. That includes real world experience in healthcare (now the strongest point on my resume) and research opportunities by marrying simulation to the econ questions of my professors.

**Alma Frankenstein:**

I'm coming to the Systems Science program from PSU's social work program. Systems thinking is largely absent--and badly needed-- both in the School of Social Work and in social services generally. We need to focus on correcting policy problems, rather than doing triage once the damage is done.

**Katie Winters:**

Hello, and thank you for the opportunity to comment. I am a doctoral student in the School of Social Work and have taken Systems Science coursework and attended numerous brown bag lectures. The Systems Science program is such a value add, from my perspective, that I applied to the Social Work PhD program here at PSU BECAUSE there is a Systems Science program on campus. I see systems thinking as the path forward for social research and am eager to take additional courses for my cognate electives as I continue through the program.

**Tamara Sale:**

I am Director, EASA Center for Excellence. In our work supporting national implementation of evidence-based early psychosis services, our understanding and approach is significantly informed by systems science. In particular, we are seeking to better understand how complex medical, behavioral, financial and regulatory environments interface within different cultures and levels of urbanicity, and how intentional use of different leadership, training and organizational strategies can support successful adaptation and implementation of evidence-based practices. I think that systems science needs to be much more broadly utilized and understood throughout PSU's programs.

**Christina Nicolaidis:**

I am PSU Professor in the School of Social Work & Director, Social Determinants of Health Initiative. I wanted to note that the System Science Department at PSU has had an incredible effect on my work.

I have collaborated with Dr. Dora Raymaker, recent alum of the PhD program, on my community based participatory research projects on autism and disability for the past 10 years. We started working together when she was a Masters student in the program; I then hired her full-time for a few years after she completed her Masters, and continued working with her when she returned to get her PhD. Dora has infused systems thinking throughout each our projects. In particular, she has brought many important theories and practical skills to our work, ensuring that our partnerships are learning organizations. During this time, we have successfully obtained several grants from the NIH and CDC

and have published about a dozen papers. I can't imagine that our projects would have been anywhere as successful without Dora's systems science concepts and skills.

Systems Science faculty and students are also involved in the University-wide Social Determinants of Health Initiative (SDHI) I lead. Dr. Wakeland and Dr. Raymaker regularly attend our weekly SDHI Scholarship and Research In Progress series, offering extremely valuable inputs, from their systems science perspective, to help each week's presenter improve their research. Dr. Wakeland and several of his students also regularly attend our SDHI Substance Abuse Consortium meetings and other substance-abuse-related events. Again, their systems science perspective is extremely important as the group tries to tackle the very complex issues related to the substance abuse epidemic in our country.

I would love to see greater support for Systems Science at PSU!