Teaching Complexity Science to Undergraduates in the Social Sciences

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A. THE CHALLENGES OF TEACHING COMPLEXITY

Teaching complexity science to undergraduates is not an easy task, particularly for students majoring in the social sciences. There are three major reasons, which must be addressed in order to successfully teach this material.

1. First, many of these students do not have a rigorous mathematics or computer science background and they tend to lack a firm grasp of physics or biology—the two disciplines (other than economics) in which complexity science has made its most significant advances. As such, most students lack the necessary intellectual background and vocabulary necessary for engaging and applying the concepts of complexity science to their own future work in such fields as sociology, psychology, social work or criminal justice.

2. Complexity science has yet to make its way to an undergraduate audience. The failure of complexity science to reach undergraduate social science majors is well demonstrated in the absence of any introductory undergraduate textbook. The only available options are advanced readers—written for professors and graduate students—or undergraduate textbooks, written for mathematics and computer science majors. Both types of textbooks overwhelm most social science students, repelling rather than drawing them toward these new ideas.

3. Complexity science and its numerous insights are spread out across a tremendous number of disparate disciplines, fields of study, and areas of research, making the task of assembling this knowledge into a coherent picture rather difficult. In fact, other than Fritjof Capra's brilliant Web of Life (1997), such a comprehensive overview for an academic audience has not been attempted. The closest anyone comes is writing excellent overviews of various areas in complexity science, such as the new science of networks or agent-based modeling.

B. THE SACS WEBSITE

The Sociology and Complexity Science (SACS) Website was specifically created to address the above three challenges to teaching undergraduate social science majors about complexity science.

The bias of this website is toward sociology, but its overview of complexity science can be used in just about any introductory social science course, including methods and statistics courses.

The strength of this website as a teaching tool is that its tremendous number of links to the World Wide Web and internet, along with a variety of short essays and chapters from our forthcoming book on SACS—all of which can be downloaded and read—provide students an easy foray into mathematics, computer science, physics and biology. All of this information also provides students an historical background in the fields of cybernetics and systems science, as well as an overview of the major topics in complexity science, including most of the major figures in the field.

With that said, the following are a list of teaching recommendations, most of which suggest ways of using the SACS Website in the classroom.

C. TEACHING RECOMMENDATIONS

1. Introduce students to the idea of world that is becoming increasingly complex: globalization, environmental issues, international economics, a faster world, etc. This complexity is coupled with the increasing complexity of science: human genome project, the informatics revolution, the development of the computer, etc.

2. How do we, as professionals, handle this complexity? How does a business handle the complexity of global trade? How does a scientist deal with so much information?

3. Introduce the concept of system as a term used to handle complexity. Complex systems are a type of system.

4. Use the Complexity Map to provide students an historical overview of the systems tradition, starting with systems biology, Gestalt psychology, systems science and cybernetics. Also point out how the last two fields simultaneously contributed to the complexity they studied through their many advances in computer science and mathematics.

5. As a general reader, the first five chapters of Fritjof Capra's ***Web of Life*** are very useful as a historical overview of the currents leading to the creation of complexity science.

> As a side note: the introduction, with its heavy bias on eco-literacy will bother some students, but it does create good discussion in class.

6. Use the Complexity Map to overview the concept of a complex system and its key areas of study: self-organization, emergence, autopoiesis, system dynamics, and the new science of networks. Capra's book is also helpful in assisting this review.

7. METHOD: Discuss how complexity science is ultimately a revolution in method. Scientists have always known the world is much more complex than their models. The trick is creating models of complexity that are useful. This is where the computer enters the story. The computer revolution in complexity science is not important because it discovered complexity. It is important because it discovered new and better ways to model complexity.

Here is where the Complexity Map is very useful for students. It can be used just as easily in an introduction to sociology course as it could in an advanced methods or statistics course at the undergraduate or even graduate level. And here is the reason why. Fortunately for social science students, the methods of complexity science are primarily visual—unlike a differential equation, for example, students can actually watch a move of a cellular automaton or complex network. Also fortunate for students, there are numerous visual demonstrations of these methods on the World Wide Web—which the Complexity Map provides.

Once the students have an intuitive and visual understanding of the methods, one can proceed to explore them at greater depth. In fact, an entire series of courses could be devoted just to the methods on the Complexity Map.

D. STUDENT PROJECTS:

As John Dewey expressed, there is no learning like doing. There are several things one can do to facilitate a student's grasp of complexity science and its methods. Here is a list of recommendations:

1. Use the students in class to construct a friendship network. You can begin by asking a volunteer to tell you who they know in class. Draw the student's friendship network on the board in class. Then ask those students in the network you just drew who they know and so on. As you develop the network, you can discuss key concepts: nodes, links, edges, hubs, informal and formal links, etc. You can also talk about the dynamics of the network: how does gossip spread, the annual flu, etc. Also, you can discuss how an epidemiologist might control the spread of the flu in this network by immunizing the nodes, etc. From here you can discuss much more complex networks, such as global trading, the small-world phenomenon, etc.

2. Create a discussion room on your course website. This has proven extremely useful for students because it gives them a chance to "try out" these ideas by explaining and discussing them with each other. It also allows you to immediately know what students do not understand, which you can then address in a subsequent lecture, etc.

3. Have students rewrite an existing sociological publication from the perspective of complexity science. How would their concepts change? How

would their methods change and which ones would they use? How would their results be different?

4. For an advanced methods and statistics courses, it is very useful to conduct, in real-time, a project for the students, which they can participate in and develop over the course. By doing the project in the classroom, students can work through their theoretical framework, key concepts, methods issues, and results. This is very effective because they work together with you, the professor, and each other to solve the problem. They also get to see the realities of doing complexity science research.