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LASCAC Technology-Based Instruction Projects Preliminary Report

Project Title:

"Upgrade of Econ 308: Agent-Based Computational Economics"

"Computational Laboratories for the Experimental Exploration of Complex System Behaviors: Phase II"

Administrative Unit:

Department of Economics

Dates of the Project:

Jan-October 2004

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I. Project Abstract

Computational laboratories (CLs) are computational frameworks that permit the study of complex system behaviors by means of controlled and replicable experiments. This ongoing project involves the development of CLs as computer-based instructional materials for an agent-based computational economics (ACE) course, Econ 308. ACE is the computational study of economies modeled as evolving systems of autonomous interacting agents with learning capabilities.

Under Phase I of this project (Spring 2003 LASCAC Award), two CLs were developed that capture the salient features of two renowned social science experiments. The first is Thomas Schelling's experiments with a checkerboard model of city segregation. The second is Robert Axelrod's "prisoner's dilemma" (PD) game tournament, in which PD game strategies solicited from game experts from all over the world were pitted against one another in repeated round-robin play. The first CL was completed and web published; the second CL was brought to a beta (testing) stage of completion.

Under Phase II of this project (Spring 2004 LASCAC Award), the Axelrod Tournament CL was completed and web published, and the development of a new, much more ambitious CL has been undertaken. This latter CL involves the construction of a "Hash-and-Beans Economy" in which hash and bean firms must learn to compete successfully for customers through appropriate pricing and production strategies in order to survive and prosper. The projected completion date for this third CL is December 2004.

Project Objectives

The objective of this project (Phase I and Phase II) has been the development of computational laboratories (CLs) as computer-based instructional materials for Econ 308. The focus of Econ 308 is ***Agent-Based Computational Economics (ACE),*** the computational study of economies modeled as evolving systems of autonomous interacting agents with learning capabilities. The topics covered in Econ 308 include: the complexity of decentralized market economies; design and use of computational laboratories; learning and the embodied mind; network economics; and experimental studies of specific types of market processes (labor, financial,

electricity...).[1] This interdisciplinary LAS course is now cross-listed as a regular spring offering under the Economics Program and under the Human-Computer Interaction (HCI) Graduate Program.

The expectation for Phase I of this project was that the Schelling Segregation Model CL and the Axelrod Tournament CL would permit Econ 308 students to develop and run interesting experiments involving complex system behaviors, even if they had no programming background. These experiments would give all students a hands-on introduction to complex system behaviors in simple social settings, prior to undertaking the more difficult study of decentralized market economies. This expectation was fully met. Both CLs were successfully used as integral parts of introductory take-home exercises and as platforms for course project use by several student teams.

The expectation for Phase II of this project is that the Hash-and-Beans Economy CL will permit Econ 308 students to run interesting experiments involving decision-making under uncertainty in a decentralized market economy. The intent is to use this CL both for take-home exercises and as a possible platform for course project use.

III. Project Tasks

1. **Selection of a Programming Assistant: Phase II.** My programming assistant for Phase I of this Project, selected from among the fifty applicants who responded to my position announcement, was Chris Cook, an undergraduate majoring in computer science. Based on his excellent performance, I chose Chris to remain as my programming assistant under Phase II of this project.
2. **Assignment and Oversight of Tasks: Phase II.** Under Phase II of this project, I worked with Chris to complete the computational laboratory (CL) for the Axelrod Tournament, including documentation for web publication. Currently I am currently working with Chris on the development of a much more ambitious Hash-and-Beans Economy CL that we plan to web publish and to submit for journal publication.

II. Project Plan

[1] See http://www.econ.iastate.edu/classes/econ308/tesfatsion/syl308.htm for the on-line Econ 308 syllabus.

As noted above, in spring 2003 I selected Chris Cook to be the Programming Assistant for Econ 308, funded under my 2003 LASCAC Course Development grant. I tasked Chris with the development of two CLs for the study of two famous social science models: Thomas Schelling's Segregation Model; and Robert Axelrod's Iterated Prisoner's Dilemma Tournament.

Back in the early 1970s, before the advent of commercially available personal computers (circa 1974), Harvard professor Thomas Schelling devised deceptively simple models to investigate ideas on complexity and self-organization. In particular, Schelling devised a checkerboard model to demonstrate how a city comprising agents of two different "classes" (e.g., religions, races, ages, castes, etc.), initially highly diversified, might suddenly "tip" into a highly segregated city if subjected to a small shock (e.g., some agents move out). The interesting aspect of this model is that the tipping can occur even if each individual agent has only a mild preference for not becoming isolated among neighbors of a different class. This famous model is now referred to as the **Schelling Segregation Model**, or, alternatively, as the **Schelling Tipping Model**.

Chris first developed a CL for the Schelling Segregation Model. This *Schelling Demo* is exceptionally well designed, easy to use, and highly instructive for students and researchers alike, permitting run-time visualization of the formation of city segregation patterns. A particularly interesting and original contribution of this demo is that Chris generalized the original two-class Schelling Segregation Model to permit three distinct classes of agents.

I have used Chris's Schelling Demo for take-home exercise assignments in my spring 2003 offering of Econ 308 and also in my current offering of this course. Students have been delighted with this demo, which has enabled them to design and run systematic experiments to test all kinds of interesting segregation hypotheses of their own devising. For example, one student team this spring made use of the three-class feature in a highly original way: green agents were reduced to passive objects by zeroing out their neighbor preferences, and were then systematically placed around the city as "obstacles." Experiments were then conducted to examine the effects of these various geographical obstacle configurations on the emergence of segregation patterns among the remaining two classes of agents (blue and red).

Another major component of Econ 308 is a course project requirement. Students, individually or in teams, engage in ACE research ranging from literature critiques all the way to the careful design and testing of hypotheses in the context of an originally constructed ACE framework. The purpose of this requirement is to encourage students to get involved in creative, informative, hands-on computational experiments. The availability of suitable CLs plays a critical role in permitting students with no programming background to undertake course projects of an interesting and challenging nature. In addition, the availability of CLs provides illustrative examples to guide students with programming backgrounds who wish to undertake the development of new software.

Three student teams in my spring 2003 offering of Econ 308 chose course projects involving interesting extensions of Chris's Schelling Demo. One team experimented with the introduction of "family relationships," another team introduced a rudimentary housing market, and a third team introduced preferences for income similarity in addition to class similarity to test the effects on the resulting segregation patterns.

In spring 2003 Chris also began the development of a CL that captures the salient features of Axelrod's famous Iterated Prisoner's Dilemma (IPD) Tournament. The resulting *Axelrod Tournament Demo* is well designed, easy to use, and highly instructive for students and researchers. Unlike any previous attempts I have seen to model the Axelrod IPD Tournament, this demo permits the user to set the payoffs to capture *any* 2-person game, not just the Prisoner's Dilemma game, and to set the payoffs asymmetrically so that different player types have different possible payoffs. This demo is being used for two exercises in my current spring 2004 ACE course. The objective of these exercises is to teach students about the general development and use of ACE computational laboratories (Section 3 of the course) and about the design of learning agents in strategic multi-agent settings (Section 4 of the course).

IV. Links to Examples of Products from the Project

Chris's Schelling Demo is available for downloading and installation (with an automated installation wizard that he designed) at the Schelling Demo Home Page at

http://www.econ.iastate.edu/tesfatsi/demos/schelling/schellhp.htm

This home page (publicly released through a link at my highly active ACE Interactive Demonstration Software site[2]) now ranks second (out of 2,370 hits) in a Google search on the keywords "Schelling" and "segregation" and is receiving about 200 hits a month.

Chris's Axelrod Tournament Demo is available for downloading and installation (with an automated installation wizard that he designed) at the Axelrod Tournament Home Page at

http://www.econ.iastate.edu/tesfatsi/demos/axelrod/axelrodt.htm

Chris is still expanding the non-symmetric payoff capabilities of his Axelrod Tournament Demo. Consequently, this demo has not yet been publicly released for general use. Its public release is anticipated within two weeks.

[2] See http://www.econ.iastate.edu/tesfatsi/acedemos.htm