BRINGING PRACTICUM TO THEORY-BASED SOCIAL SCIENCE DISCIPLINES:

AN ILLUSTRATION WITH A USER-FRIENDLY SIMULATION LABORATORY ON ISSUES OF ECONOMIC DEVELOPMENT

Khalid Saeed
Asian Institute of Technology
Bangkok, Thailand

ABSTRACT

This paper suggests that the possibility to experiment with relationships using system dynamics should lend the method easily to introducing practicum in the theory-based disciplines. This would however, require modifying teaching formats and creating new text materials and user-friendly computer programs suitable for use by students with little computer or mathematical expertise. A simulation laboratory consisting of a text and a user-friendly simulation program developed recently by the author on issues of economic development is presented as an example of materials needed for integrating practicum with teaching.

Keywords: Practicum, Education, Learning Systems, Social Science, Computer Simulation, System Dynamics

INTRODUCTION

System Dynamics is a heuristical procedure involving the study of information relationships, existing or contrived in a physical or social context, through construction of formal models and simulating them on a computer [Forrester 1961, 1968]. Until recently, however, System Dynamics has remained in the domain of complex modelling methodologies involving expensive computer equipment and significant programming expertise. The method has also often been identified with the global issues to which it was applied in its early stages of development and the many controversial theses it created have aroused much debate [Nordhaus 1973, Averch and Levine 1971].

Albeit, the possibility to experiment with relationships using the modelling principles of system dynamics provides a powerful means to introduce the concept of practicum, as conducted in a laboratory or a studio in learning physical sciences or some forms of arts and crafts, also in the teaching of social sciences. The introduction of personal computer and the concept of user-friendly software over the last decade have fortunately also made it possible to easily and economically use system dynamics quite widely. An opportunity has thus been created for system dynamics to become a useful experimental tool for the social sciences education instead of only remaining a method for creating complex mathematical models for research. Introducing the concept of practicum involving experimentation in the teaching of social sciences would, however, require revising the existing teaching formats and developing new text materials and computer-based learning apparatuses suitable for use with the audiences with limited mathematical or computer-related experience [Saeed 1989a].

This paper discusses the organization and the content of a book/software package entitled The Design of Change for Economic Development developed recently by the author consisting of appropriate readings explaining theoretical models of the development processes and their empirical context, and a user-friendly software which allows one to experiment with the models without having learnt the mechanics of modelling [Saeed 1989b]. This package may be suitable for use as a graduate text integrating theory and practicum on issues of economic development or as a professional reference that easily lends itself to query.[1]

THE ROLE OF PRACTICUM IN SOCIAL SCIENCE

The state of social sciences is sometimes likened to that of physical science before Copernicus and Galileo began experimenting with physical apparatus and questioning then existing conjecture-based theories. Their experimentation created a revolution in the physical science by shifting its basis from conjecture to empiricism, while also creating a traditions of practicum and reflective practice which have since become integral parts of teaching and learning in all physical science based-disciplines [Baldwin 1980, Schön 1987].

The teaching of social sciences is nevertheless conducted predominantly on the conventional lecture-style lines, emphasizing the learning of the theoretical premises without necessarily going through an involved reflective process. Concerted efforts to use formal modeling tools for experimental learning are rare, although one often hears of isolated attempts to employ user-friendly computer programming media for construction of models of organic relationships in systems and their simulation on a computer.

Any reflective practice in the disciplines relating to the social sciences would require experimentation with the perceived behavioral relationships forming part of a theory or an organizational design, which has only been possible to a limited degree. This is due to the inadequacy of the traditional methods for such experimentation, namely qualitative reasoning and formal mathematical logic. The former, being inexact, is unable to assist the reflective process in a reliable way. The latter can handle only very limited complexity while its application requires specialized skills; hence its scope is limited.

System dynamics overcomes some of the limitations of the traditional methods by providing well-defined organizing principles to develop explicit models of complex social processes and to understand these processes and create designs for system improvement through experimentation with their models. The study of the organizing principles of systems, together with the possibility of computer simulation of the outcomes of the hypothesized system relationships, provides an easy-to-use means of such experimentation [Forrester 1975, Simon 1969, Radzicki 1988].

The theories underlying many social science disciplines are quite widely known although more than one theory may exist and the practitioners may be strongly divided over which of the existing theories is correct. System dynamics modelling allows one to construct an apparatus to experiment with the perceived information relationships underlying a theory which helps to resolve debate while also making possible modifications that reconcile theories with empirical evidence. Modified theories thus constructed provide a sound basis for designing policies for system improvement.

Although, the process of developing a formal model of a process in itself is also of great value as a reflective exercise [Forrester 1985], it requires certain amount of technical skill which many people may not be sufficiently motivated to acquire. An introduction to experimentation through use of interactive software may, however, serve as an easier alternative to modeling for the uninitiated and may even create the motivation to acquire the technical skills needed for modeling. Furthermore, curricula in specific subject areas incorporating experimentation with hypothesized relationships may help to unify knowledge on the subject by allowing to corroborate and reconcile theories and test tentative designs of change [Forrester 1987]. This would, however, require redesigning the teaching format towards a variety of teaching types incorporating appropriate instructional, experimental and discourse-related components.

TEACHING FORMAT FOR LABORATORY PRACTICE

The conventional lecture style teaching in social sciences often covers methodological details, theories and empirical evidence in a series of undifferentiated sessions. A departure from this is the "case method" developed at the Harvard Business School several decades ago which, at least in theory, attempts to refine the reflective faculties. Although potentially a powerful approach, the case method, in the absence of an effective means of examining the logic of complex relationships, may often generate, discussions quite useful for the development of communication skills, but contributing little to the refining of the reflective faculties. The case method can, however, become very effective if complex relationships of a case are translated into a model which is experimented with to understand the nature of the observed problem and identify an effective entry point into the system [Graham 1988]. This necessitates building regular laboratory sessions into the teaching schedule.

A completely free-form laboratory may not be a practical way to conduct practicum since it may waste considerable amount of time in trial and error creating much frustration and little learning on the part of the student. Teaching in the laboratory format, therefore, also requires supervision of the laboratory work. The students, working in small groups, may engage quite independently in experimentation with custom-built, user-friendly programs based on system dynamics modeling, allowing the students to select relationships and decision rules of their choice and study their behavioral implications. The user-friendly software would allow a focus on the problem area without the distraction of the modelling detail. But, as their work progresses, they should also be able to interact informally with the supervisor as in a music or art studio. The supervisor's task, however, may not be to have the students converge on a single solution to the problem they are attempting to address but to facilitate their thinking towards developing their own designs, thus creating a large variety of potential solutions. Such a laboratory session would provide an appropriate environment for the students to experiment with and reflect on their own ideas while the supervisor facilitates the process.

Laboratory sessions can be organized only if the student is first familiarized with the basic theories and the design problems existing in the area. He must also be helped with preparing an experimental design before undertaking any experimentation. The laboratory sessions must, therefore, be preceded by lectures explaining the models and discussing the possible points of intervention. Furthermore, the variety of ideas generated in the laboratory must be compared and critically examined by the class in plenary discussions to facilitate productive discourse among the students. A course shall contain a number of sessions covering above agenda.

With the commercial availability of software such as *DYNEX*[2] [implemented on IBM PC/XT/AT/PS-2 or compatible machines] and *STELLAStack*[3] [implemented on Apple Macintosh], custom-built software for use in specific theory-based disciplines can now be developed with relative ease by the expert practitioner with limited computer programming experience. Following section of this paper outlines the content of the text/computer program prepared by the author which may be suitable for use in teaching and learning in a laboratory format. This package has not yet been formally implemented in the classroom but has undergone extensive testing and review by the author and his peers.

A LABORATORY ON ISSUES OF ECONOMIC DEVELOPMENT

A book/software package entitled "The Design of Change for Economic Development" has recently been developed by the author for experimental learning on economic development issues. The contents of this package are organized into three parts: 1) the main text of the book, containing discussions of the structure of the models provided for experimentation and the related empirical evidence, and the key experiments performed by the author and inferences made from them; 2) the technical appendices containing mathematical details of the models and operating instructions for the software; 3) two floppy diskettes containing the software, which can be implemented on any IBM personal computer or compatible machine.

Figure 1 outlines the organization of the software. Three base models incorporating widely recognized theoretical premises relevant to the subject constitute the core of the software, serving also as a starting point for experimentation. The base models have, however, many built-in switches which allow alternate sets of equations to be interchanged. This facility makes possible modifying controversial assumptions through parametric changes. A modified model constructed by the user further lends itself to implementation of many policy options. The magnitude and timing of these policy options can also be specified. Finally, the finished model incorporating modifying assumptions or selected policy options or both is sent to the simulation module which simulates and allows to display and print the behavior of the selected variables.

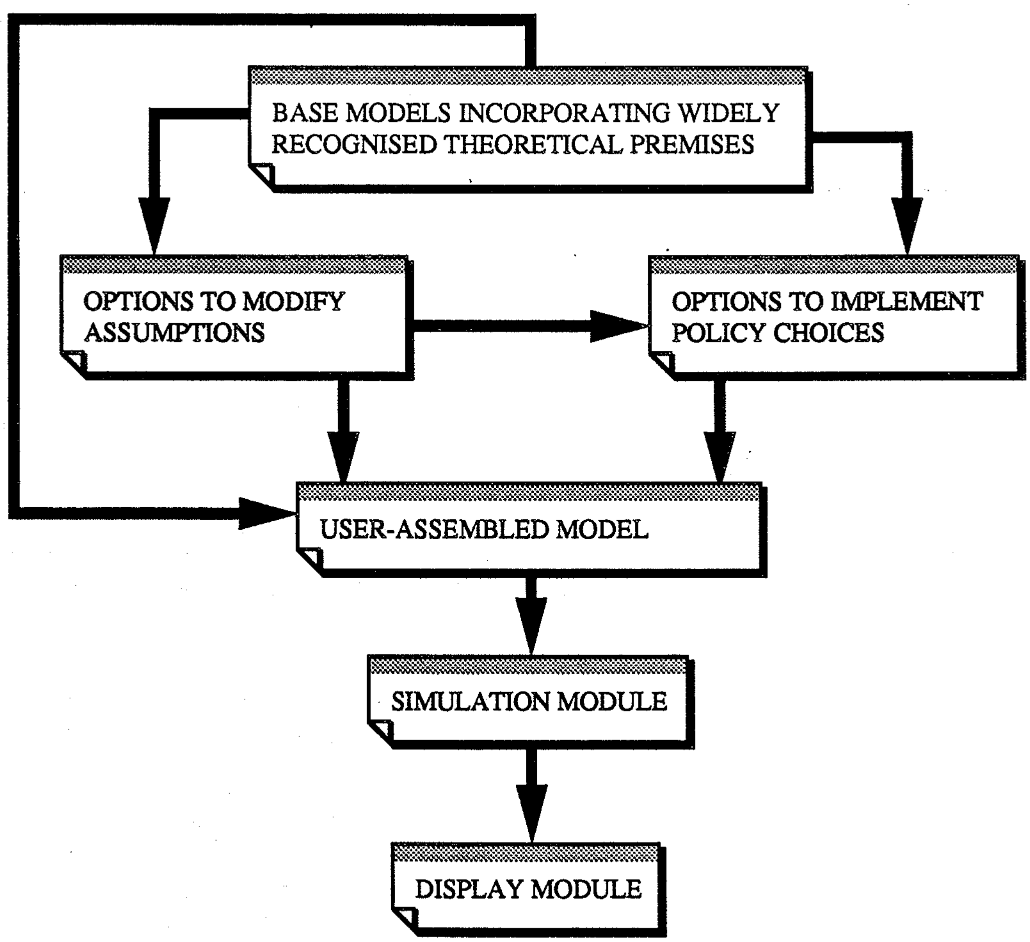

Figure 1: Structure of the Simulation Software

The software is based on a commercially available programming package, Profession DYNAMO Plus[3], although a batch file written in Basic had to be constructed to provide access to multiple models through a single menu system. All menus have been prepared in simple English. By following these menus, one can assemble a model with the assumptions of one's choice and also make policy runs with any number of policies selected from the menus. A few examples of the menus are shown in Figure 2. No programming or other computer-related experience is needed to experiment with this software, although knowledge of system dynamics and feedback concepts would help greatly to interpret the simulations.

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RADICAL LAND REDISTRIBUTION

You may simulate radical land redistribution policy by
transferring land from one sector to the other at a
designated time.  Select one of following choices -

1. Transfer 10E6 units of land from Formal to Self-Employed
   sector

2. You will specify the quantity of land transferred
   (Negative value implies a transfer from Self-Employed
    to Formal sector)

3. No change, skip this policy

Type your choices (1, 2, 3) and press Enter key -
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PRODUCTIVITY IMPROVEMENT

 Select one of following choices:

1. Productivity is increased by 50% at designated time

2. You specify fractional improvement in productivity

3. No change, skip this policy

Type your choices (1, 2, 3) and press Enter key -
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COMMUNITY DEVELOPMENT EFFORT

Community development effort allows organization of Self-
Employed so they are able to use modern capital.
Select one of following choices

1. Community Development policy is introduced at time 100

2. You specify time of introduction of community development

3. No change, skip this policy

Type your choice (1, 2, 3) and press Enter key -
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Figure 2: Examples of menus appearing on the computer screen

The book/program package can be used for self-learning or in a formal course or professional development workshop incorporating three types of sessions: 1) Short sessions of about one hour to discuss fundamental organizing principles, which in this case include the assumptions and the structure of the models and their empirical context, and the design of simulation experiments; 2) Supervised laboratory work stretching over about three hours to experiment with the custom-built software; and 3) Plenary discussion sessions of about an hour and a half for group discourse. The text and models of the package cover following agenda.

i) Partitioning a Complex Problem
To reduce the complexity of formal modelling, the problem should be partitioned into smaller components provided that this does not disconnect important symbiotic processes subsuming experience over time and geographic location. Following these guidelines, the developing country system is partitioned into three subsystems: 1) social relationships of production and income distribution and the demographic processes, 2) ecological and technological factors governing the utilization of natural resources, and 3) political relationships affecting the ability of the government to support public welfare. Computer models of the subsystems thus created allow experimentation on a wide variety of issues on economic development.

ii) Economic Growth and Income Distribution
The relationships underlying the behavior of the actors in the economic system are explained. Students are introduced to the software and encouraged to experiment with it to gain familiarity with its working. They may be assigned to create various patterns observed in history and to attempt to explain them.

iii) Evaluation of Impact of Development Policy
Experimentation with known or arbitrarily conceived development programs and attempts to explain their simulated outcomes cultivate the realization that impromptu policies, even if they are well intended, may be quite ineffective in the face of the internal trends of the system. This experience should cultivate careful thinking attitudes and thus promote reflective practice.

iv) Policy Design for Economic Development
The analysis provided in the main text identifies two types of instruments for changing wage and income distribution patterns -- those creating the fundamental forces of change and those facilitating change. The fundamental instruments may significantly alter an internal trend, while the facilitators may only enhance an existing internal trend.

Experimentation with the model of the growth and income distribution system permits the combining of the fundamental and the facilitating policies in designing an appropriate path of change according to the government's ability to intervene and to cope with such a change.

v) Policy Design to Alleviate Food Insecurity and Poverty
Experimentation with the model of social relationships and demographic processes also leads to a recognition of the resilience of the system to policies which directly address the symptoms of poverty and hunger. These policies include agricultural development, financial and technical assistance for the poor and population control, but may all be defeated in the long run since the socio-technical arrangements of the system favor persisting poverty and vulnerability to food shortage.

The experimentation also creates an awareness that the solutions to the problems of poverty and hunger may lie in attempting to influence the internal goals of the system. A variety of instruments for this can be experimented with.

vi) Material Resources and Environmental Considerations
The model of the ecological and technological factors governing the utilization of natural resources addresses the controversy arising from the comparison of the criteria of the neoclassical and the environmentalist models. These are internally consistent, but otherwise have little overlap.

Experimentation with this model leads to the recognition that a sensible resource use policy must incorporate considerations of both the throughput and the boundary interaction of human society with its resource environment. A variety of designs can be attempted by the students to meet these considerations.

vii) Technological Development
The adoption of technologies in the developing countries has generated a wide variety of performance patterns, which has confused the issue of what might be an appropriate choice. Experimenting with the various models of the package allows an examination of the problem of choice of technology taking account of the dynamic systems representing the political and social organizations and the resource environment in which the selected technology must function.

viii) Entrepreneurship Development
No discussion of the development process is complete without taking into consideration the human motivational factors, in particular those affecting entrepreneurship and innovation.

Many situational views are found in the literature concerning entrepreneurship whose coverage constitutes the starting point of the discussion on this subject. This is followed by an effort to develop a framework for entrepreneurship development through a comparative analysis of the situational views together with the inferences made through experimentation with the computer program provided with the book. The experimentation creates recognition of the motivational, organizational and infrastructure-related factors for stimulating and supporting entrepreneurship.

ix) Government's Role
No design for economic development and change should ignore the government's role since it is impossible to implement development agenda without government support. The model of political relationships incorporates organizational mechanisms that determine whether a government is able and willing to support development agenda.

Experimentation with this model creates the recognition that the ability and willingness of a government to implement development agenda cannot be taken for granted, and that the existence of a suitable political environment is critical to sustained government commitment to public welfare. Students may experiment with a variety of relationships to create designs of an effective political organization.

The introduction to each set of issues is followed by well-designed experimentation addressing those issues. Guidelines for the design and conduct of the experiments are provided when the issues are introduced. As in the case of the course on system dynamics modelling, the experimental results are critically examined in the plenary discussion sessions. The custom-built software allows the students to focus on the issues without being distracted by the technical details of computer programming. The course materials have received very positive peer reviews, although the author has not yet used it in a formal classroom setting. A copy of these materials can be obtained from the author on request.

IMPEDIMENTS TO IMPLEMENTING LABORATORY TEACHING

The laboratory teaching in social sciences is currently difficult to implement for the lack of teaching materials needed for it, since most currently available texts are organized on conventional lines. There have, however, been isolated attempts made at developing such materials, presented as games or "flight simulators" which are designed for specific contexts.

The bundling of STELLA software with extensive text materials represents one of the few attempts to create an experimental learning package on system dynamics modelling [Richmond 1987, Saeed 1989c]. An example of a subject-specific learning laboratory is the user-friendly computer program and text developed by the author discussed in this paper. Few other serious attempts have been made to create learning media combining the discussion of theory and empirical evidence with experiment.

Even the scarce available materials for laboratory teaching may not be used effectively unless teaching formats are also modified. At the same time, the development of new teaching materials may not proceed smoothly unless innovative teaching formats incorporating supervised laboratory sessions already exist creating the demand for such materials. This chicken and egg problem can be solved only if concomitant efforts are made to develop teaching materials and innovative teaching formats incorporating laboratory work.

CONCLUSION

Experimental learning is an important means of developing reflective faculties. While it is a key element in instruction in the physical sciences and some forms of fine arts education, it is rarely incorporated into social science instruction. The system dynamics methodology can be easily adapted to develop curricula using experimental learning in the social sciences. This does, however, entail modified teaching formats and the development of text materials for the new formats.

This paper demonstrates how the system dynamics method can be effectively applied to laboratory teaching in the theory-based social science disciplines. The teaching formats must change towards a variety covering focussed discussions of principles, supervised experimentation with relationships and plenary discussions providing opportunities of group discourse. Existing text materials are, however, inadequate for supporting laboratory teaching and currently much improvisation is required to incorporate experimentation into the instruction. Considerable further effort at laboratory teaching and developing text materials for use in such teaching are needed before the approach becomes widespread.

NOTES

1. Draft version of the package is available from the author on request for the cost of materials and mailing.

2. Available from High Performance Systems, 13 Dartmouth College Highway, Lyme NH 03768, USA

3. Available from Pugh-Roberts Associates, Five Lee Street, Cambridge, MA 02139, USA

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