

ABSTRACT

A Systemic Approach to System Dynamics Education: A Status Report

Andrew F. Smith and Allen Boorstein
Amber Blocks; 147 East 48th Street; New York, NY 10017; (212) 230-9864.

System Dynamics Education (SDE) efforts have been underway in the United States since the 1970s. Since then, pre-collegiate educators have attended System Dynamics (SD) conferences, participated in training workshops, developed and distributed curriculum materials, launched projects, published articles and completed dissertations. In October 1995, the authors have interviewed teachers and administrators involved in SDE projects, analyzed curriculum materials, and reviewed the literature. Based upon this data, strengths and weakness within the SDE field have been identified, and recommendations have been developed. This paper is a progress report intended to promote dialogue among those interested in SDE. We encourage others to challenge these recommendations and substitute alternative ones.

1) Curriculum Change Strategies and SDE Efforts. Many believe that SDE has the potential to revolutionize teaching, learning and school structures. However, SD educators express no common vision for what a SD school might look like. Others believe that SDE was simply one tool among many which could be used within the existing schools. Where educators have feared to tread, leaders in business are moving in. Arthur Andersen, for instance, has developed plans for a new school based largely in learner-centered learning, systems thinking, and other innovations. While this experiment may not answer all concerns, its creative approach may help future SDE efforts.

Recommendations:

- 1.1 System Dynamicists should develop models and computer simulations which focus on educational problems and issues.
- 1.2 Schools implementing large chunks of their program around SDE should be carefully monitored and evaluated.
- 1.3 SDE projects should include components for helping educators envision what SDE schools and school systems might look like.
- 1.4 SDE efforts should consider collaboration with local business using systems thinking.

2) Projects and School-based Programs. Nine main hubs of SDE are, or have been, active. Geographically, these sites are: San Francisco Bay area, California; Portland, Oregon; Ridgewood, New Jersey; Tucson, Arizona; Brunswick, Glynn County, Georgia; Concord, Massachusetts; San Antonio, Texas; Brattleboro and Burlington, Vermont. In addition many isolated teachers and a few other schools are engaged in developing SD programs. It is not likely that the total number of educators who are currently active in SD field exceeds 2,500. Almost all teachers interviewed strongly supported the basic principles of SDE. All reported greater student enthusiasm for SDE activities as opposed to traditional instructional techniques. The reasons for this enthusiasm included learner-centered learning inherent within most SDE materials; the Hawthorne effect; and the excitement of using computers in ways other than as glorified typewriters. An unexpected finding related to the positive effect of SDE programs on previously identified "low-achieving" students. Similar positive results were reported for students of diverse ethnic/linguistic backgrounds. The reasons offered for these findings include: SDE may well

reach students who are not turned off by teacher-centered programs; the diagrammatic component may provide a different way of learning than the typical lecture/regurgitate format; the interest may really result from exposure to the computer, and not with SDE; and the "aha" feature of discovering for oneself how things work.

Despite their enthusiasm, almost all teachers expressed concerns. Problems included the amount of time necessary to implement SDE programs in classrooms. Many teachers were unable or unwilling to make such a major commitment without release time from their school and other benefits. Many teachers complained of lack of administrative support. Administrators, even those who were supportive of SDE projects, looked upon SDE as an interesting curriculum project for teachers. School administrators saw little relevance of SDE to their own decision-making activities. Finally, many SDE programs were strapped for funds.

Recommendations:

- 2.1 Existing SDE efforts need to be continued and strengthened.
- 2.2 New SDE efforts need to be launched, ideally capitalizing on trained personnel from existing projects who could serve as change agents in other projects.
- 2.3 More work needs to be undertaken to involve administrators in SDE projects.
- 2.4 Foundations currently funding SDE efforts need to encourage other foundations to invest in SD projects.

3) Teacher-Developed Curriculum Materials and Computer Software Used in SDE Programs. About 150 teacher-made curriculum materials are available through the Creative Learning Exchange (CLE). Many CLE materials were developed by teachers in SDE projects. The materials vary in quality. As curriculum materials are now increasingly available, there is now movement toward screening materials before they are accepted for distribution. The majority of curriculum materials have been developed in the sciences. Relatively few are directly applicable to social studies and the humanities. Fewer materials are currently available at the elementary level.

SDE rests upon the use of computer simulations. Two major categories of computer simulations are used by SD educators. The first are those computer simulations which model specific systems. These simulations are fairly sophisticated and relatively easy for teachers and students to use. In addition these simulations more easily fit into the existing curriculum. The disadvantage is that the models presented are often hidden and the structure cannot be manipulated or changed by students or teachers. Participants may end with little understanding of the system being simulated or how to alter it. The second category of computer simulations used SDE are generic software applications, such as *Inspiration* and *Stella II*. These simulations make it possible for students or teachers to create their own models.

Recommendations:

- 3.1 Special efforts should be made to develop curriculum materials for those levels and subject areas under represented by the current available materials.
- 3.2 SD materials related to courses presently offered in schools need to be developed.

4) Teacher Education Programs. A major finding uncovered in this survey was the need for extensive teacher education programs. Educators cannot simply read the latest book on SDE and

teach it the following day. At the best level of SD teacher education programs, teams of teachers were trained during the summer workshops and follow-ups occurred during the academic year. Teachers were then expected to change their teaching using the tools learned during the SDE programs. Many teachers simply drifted away. SDE has been more successful in particular subjects taught in secondary schools, such as science and mathematics. In general, social studies and humanities teachers are less inclined toward SDE, although there are exceptions. Many teachers are unwilling to expend the extra effort necessary to infuse SD into their curricula, partly because there are fewer curriculum materials available.

Recommendations:

- 4.1 Long-term, in-depth, hands-on experiences for educators are necessary for successful implementation of SDE programs into classrooms. To be successful, these programs must work with teams of teachers, or entire faculties from specific schools.
- 4.2 System Dynamicists and professional teacher educators need to develop models for use in teacher preparation programs in colleges and universities.
- 4.3 Programs need to be offered for school administrators and policy-makers which identify the basic tenants of SDE and suggest ways in which these tools can be used to improve school administration and governance.

5) Research and Evaluation. Most SDE projects have difficulties. Projects have reported over-optimistically about their progress. The reasons for these rosy reports include: many SDE projects have made good progress; SDE project staffs are well aware that funders do not like to hear about lack of success; and those who have continued in SDE efforts over time tend to be enthusiasts who strongly support the project.

While specific project goals may well have been met, it should be recognized by System Dynamicists and SDE project staff that schools are complex institutions and are extraordinarily difficult to change. Teachers, administrators, parents, students and taxpayers all have mental models of what schools should be like. SDE models may suggest radically different approaches to schooling. Educational constituents tolerate short term shifts in the curriculum, but on the long run may want to reestablish the status quo. There is always fear of real change. Parents have a legitimate fear that innovative programs in elementary and secondary schools will affect their child's ability to enter into the university of their choice. Universities need to learn about SDE and explicitly encourage the acceptance of students who graduate from SDE programs.

Recommendations:

- 5.1 All SDE efforts expend resources on accurate and honest evaluation.
- 5.2 Collegiate System Dynamicists should encourage graduate students to conduct research into pre-collegiate SDE projects; alternately SDE projects and programs should encourage graduate students to become part of their programs.
- 5.3 Researchers interested in SDE should meet periodically and set priorities.
- 5.4 A small grant should be sought to help meet research and evaluation priorities.

6) Dissemination. The Creative Learning Exchange (CLE) is the main dissemination mechanism within the SDE field. It was created in 1991 by the Bemis Foundation to promote the dissemination of materials and information about SDE. Of the many materials available from the

CLE, most were examined.

Recommendations:

- 6.1 Educators in SD projects should be encouraged to offer presentations at state and national subject-area conferences.
- 6.2 All SDE curriculum material should be evaluated by System Dynamists and professional educators.
- 6.3 The CLE should develop, publish and market books (with computer disks as appropriate) composed of carefully selected teacher-made SDE curriculum materials.

7) Conceptualization and Articulation Issues. Despite extensive work undertaken in the conceptualization of SD, its definition and its implications for elementary and secondary education remain unclear. Most educators could not define SDE except in terms of citing authorities and offering vague notions of stocks, flows and feedback loops. Guidelines for SDE in K-12 are needed. Students will need years of contact and exploration with SDE before the real payoff will unfold.

Recommendations:

- 7.1 System Dynamicists and those engaged in pre-collegiate SDE need to meet and agree upon a clear and concise definition of SD, and develop a clear rationale why SDE programs are necessary and beneficial.
- 7.2 System Dynamics educators need to develop articulated K-12 Guidelines.

8) Education as a Complex System. The greatest potential benefit from the use of system dynamics is as a management and administrative tool for improving education and comparing the effects of particular proposed educational changes in advance of their use. Models of education processes, structures or problems can be developed at local schools and school districts. These models could be developed cooperatively by school administrators, teachers, parents, students and other stakeholders. Participants in developing models are more likely to assist in implementing policy recommendations that emerge. Potential issues, such as merit pay for teachers, vouchers, main-streaming, parental choice, or drop out prevention programs, offer excellent opportunities for SD to examine. On each topic, educational policy-makers can investigate alternative model structures. These potential applications contain as yet unrealized potential payoffs of SDE.

Recommendation:

- 8.1 SD models need to be developed at the school and school district levels focusing upon existing problems confronting education.

Conclusion

SDE efforts need strengthening. If they are to survive and thrive, greater emphasis needs to occur on evaluation, teacher education, improved curriculum materials and textbooks, conceptualization and articulation, and broader dissemination. SD tools need to be used to examine controversial issues related to school governance and school reform. If SD tools can help understand and improve complex social systems, then there is no more important place to employ them than in elementary and secondary school education.