IS SYSTEMS DYNAMICS RATE OF DIFFUSION SLOW ?

Andres Esteban Breiter
A.B.C.-Techniche Avanzate di Gestione

Abstract. This paper examines the causes and effects that interact to determine the rate of Systems Dynamics diffusion.

The use of Systems Dynamics implies both a way of conceptualizing the models of existing systems and the use of such models to gain a better understanding of the systems' behaviour.

Given the high potential of Systems Dynamics to aid in understanding a very wide variety of systems in many areas of human endeavour the Systems Dynamics practitioners worry regularly about its slow propagation and frequently express anxiety about the future of the field. They tend to forget, however, that the potential usefulness of their approach is obvious to them but is hard to appreciate by the would be users and eventual beneficiaries of the improved solutions derived from applications of their expertise.

This paper focuses on the causes and effects that in the authors' opinion interact in the diffusion of Systems Dynamics and suggests actions that may eventually help to accelerate the process of its broad adoption.

INTRODUCTION

Systems Dynamics appears to the practitioners as endowed with great potential to be successfully applied in all sorts of professions and occupations to a great variety of problems. It is this vast potential for application and the great usefulness that is perceived by those who understand the new approach that makes them feel deeply frustrated over what they perceive to be a slow rate with which their "truth" gains acceptance.

A closer examination suggests that although there is a considerable scope for accelerating the diffusion of Systems Dynamics its ultimate influence on our culture is likely to be so pervasive that perhaps its full potential will not be achieved for several generations to come.

In this perspective the progress achieved so far over the past quarter of a century may be quite adequate indeed.

The rest of the paper discusses what the Systems Dynamics professionals do that may slow down or accelerate its rate of propagation.

To begin with, the mostly unjustified feelings of frustration with Systems Dynamics rate of diffusion should be understood and it should be transformed into positive actions. With this objective in mind are presented in the second section the key causes that contribute to the generally low level of awareness about Systems Dynamics potential in aiding to deal with complex problems.

Common difficulties experienced by beginners in their first applications of Systems Dynamics are described in the third section drawing on direct observations by the author.

The typical road blocks encountered in proposing the use of Systems Dynamics to would-be clients are described in the forth section where also several solutions are proposed.

In the fifth section overall prospects for the field are explored and are found bright since the approach is likely to penetrate most occupations and professions in the long run.

Finally, in the last section, actions that would help to accelerate the growth of Systems Dynamics are described.

I
THE UNJUSTIFIED FEELING OF FRUSTRATION WITH SYSTEMS DYNAMICS RATE OF DIFFUSION.

Most discussions about the use and diffusion of Systems Dynamics give the impression of dissatisfaction among the practitioners with the slow rate with which the approach is being accepted. Based upon this author's experience it is suggested that this reflects the relatively frequent rejection suffered in attempting to solve problems employing this method.

The rejection has historically been also suffered by many prophets who were preaching their truth and by many pioneers in the most varied fields. This is the price the pioneers must pay for their willingness to play their role.

It is useful, however, to understand the underlying causes of this frequent rejection of Systems Dynamics by its would be beneficiaries who do not realise the wealth of insight they are loosing by refusing to be helped with the use of this innovative and powerful way of attacking complex problems. This

understanding may be useful if we want to avoid the negative effects of frustration and instead to build on this negative experience to promote the use of Systems Dynamics for the greater benefits to mankind. In other words we have to apply constructively the old saying, fashionable over 30 years ago, stating that "dissatisfied engineers and scientists are essential elements of progress". This is so not because they are frustrated but because their dissatisfaction should propel us towards new and better solutions.

With the objective of helping to increase the number of successful applications we shall now look at the causes and effects that interact in the final acceptance or rejection of proposed Systems Dynamics approaches to dealing with various problems.

II
THE LIMITED GENERAL AWARENESS ABOUT SYSTEMS DYNAMICS POTENTIAL IN STUDYING TREATMENT OF COMPLEX PROBLEMS.

Systems Dynamics was born about a quarter of a century ago and since then it has been applied by a relatively limited number of practitioners to the solution of many different problems, frequently with considerable success. Why then is the awareness about its potential limited ?

Two reasons contribute to this low awareness about Systems Dynamics potential:

1.- Secrecy of many Applications.

Many important problems to which has been applied because of their nature required that there should be no publicity about the methods through which the solutions have been arrived at.

In this authors' knowledge this has been the case of several strategic studies for government agencies and for industrial companies. National security related policies and economic strategy studies in which governments are interested as well as strategies developed by governments against criminal organizations, usually represent subjects that tend to be covered with blankets of secrecy. Even when public discussion does take place the method and thinking through which the final policy was developed tends to remain confined to a small number of people. Secrecy also tends to be extended around company sponsored strategic studies employing Systems Dynamics.

At least one company that arrived at the choice of its organizational structure through Systems Dynamics analysis while widely publicizing the new structure and its mode of operation maintained total silence about the method through which the structure was arrived at. The article describing this structure became a classic in the organization literature of the '70s but it does not even indirectly suggest the kind of efforts that went into the design.

In other words the frequently prevailing attitude appears to be "we can tell you what we are doing but not how we do our thinking". It is this last aspect that involves Systems Dynamics and limits the wider awareness about its usefulness.

This behaviour closely resembles that of a French gourmet who enjoys his preferred tiny restaurant but will not tell even his friends about it for fear that once its existence becomes widely known, the patronage will become numerous and the quality of food will deteriorate.

There have of course been problems of general interest that were studied with the help of Systems Dynamics and received wide publicity. Among them the best known example is probably "Limits to Growth" (1). This publicity did not contribute as much as could have been expected to the general awareness about the potential of Systems Dynamics probably because:

A.- The focus of the publicity has been on the results of the study rather then on the methodology employed.

B.- The studies are generally perceived as being conducted by some remote highly trained groups of scientists using methods too complex, costly and time consuming for their application to the problems that are deemed to require quick and simple solutions.

2.- Our educational System has yet to Incorporate Systems Dynamics in its Curriculum.

There is little doubt that given its vast potential Systems Dynamics will eventually find its way into most formal study programs. However, this has not yet happened and therefore rarely have contemporary decision makers become aware about it during their formal studies. In addition most updating courses if ever attended by them, busy as they are, tend to be contained within the framework of references originally acquired and such framework tends not to include conceptualization of systems in which causes and effects interact over time with feedback effects.

In fact this author has found time and again that many people experience considerable difficulty in imagining how a system will behave over time if subjected to various external pressures or in response to different decisions taken by decision makers operating on the system. This kind of visualization can be frequently developed by training just as training improves visualization of objects in space when reading blueprints.

III
FRUSTRATIONS EXPERIENCED BY NEW SYSTEMS DYNAMICS ADEPTS AND THEIR HIGH FAILURE RATE IN EARLY APPLICATIONS.

When a new Systems Dynamics adept tries to apply his (her) powerful tool he quickly finds out that model building not only requires a full mastery of the technique but it also requires knowledge about the system being modelled. Furthermore, at least for now, it is an art which must be learnt through the painful process of trying, failing and trying again. This requires time and a considerable resistance to frustration.

The discovery is made as soon as the would be model builder tries to solve his first problems applying the knowledge acquired during his training. He usually starts out using a model he has in his tool box which he then tries to adapt to the situation on hand. If the model is sufficiently close to the requirements the exercise may prove a success and the apprentice may feel encouraged to proceed further.

This however tends not to be the usual case. The requirements for the model are generally such that considerable additional conceptualization may be needed and this is not taught as an exact process. Furthermore this conceptualization must be acceptable to the client and it must be adequate as foundation for the equations of the simulation model to be built later. Very frequently the efforts to build a model are abandoned at this stage and the new Systems Dynamics convert is lost to the field and so may be his client.

Let us now assume that the new adept has successfully developed the conceptual cause-effect model and has adequately taken into account the delays. He still needs to convert the concept into equations and he has to master the understanding of which loops exercise control over the system under various conditions. Both steps are not sufficiently well developed in the literature to guide him through the dangerous grounds he must cover and few

newcomers successfully reach the promised land of seeing their models validated and used for policy testing or other applications.

Most courses without stating it explicitly introduce students to Systems Dynamics in terms adequate to become its devoted users rather then practitioners and this causes a considerable frustrations and a high rate of failures in early applications.

IV
PRESENTING THE SYSTEMS DYNAMICS CASE CONVINCINGLY TO EVENTUAL CLIENTS.

Given the lack of general awareness about Systems Dynamics potential, the practitioner faces the complex task of making his potential client aware of the approach while at the same time getting him sufficiently interested in it to try it out on his problems.

Frequently Systems Dynamics practitioners are only too well aware about the potential contribution their approach could make. To succeed, however, they must usually meet the following conditions:

1.- Understanding the Terms of Reference of the eventual Clients.

This requires at a minimum some capabilities for empathy, a minimum understanding of the clients motivations and some knowledge about the outstanding features of the problem.

2.- Anticipating potential Insight and Treatment for the Problem in Question.

Given that in many cases insight is gained only once the model building is under way this implies that frequently a substantial effort must be undertaken long before there is a clear-cut agreement with the prospective client about the initiation of the study and its objectives.

3.- Presenting the Insights in Terms easily Understandable by the Client.

This requires some experience and perhaps some training. It is important to tell the client first what he is interested in. It is important not to distract him with what the practitioner finds as the most interesting aspects of the work and finally

it is important to use plain and simple language and not the technical jargon generally obscure and frightening for the client.

4.- Doing all the above within the Time Span limited by Clients' Concentration on the proposed Approach.

This probably represents the greatest constraint of them all. It requires that the Systems Dynamics practitioner should acquire a considerable wealth of information and spend a lot of effort on doing his homework before opening discussions with his eventual client.

Given time most of the bright Systems Dynamics professionals could probably learn enough about the client problems to present their case adequately but frequently time is limited and if the client decides that the would be consultant does not understand what he or she is talking about, the exercise is usually over.

Satisfying the above 4 conditions is frequently very difficult because the Systems Dynamics experts tend to be well versed in their technology but are not in the possession of sufficient knowledge and facts about the specific problems and clients they are dealing with.

V
THE PROSPECTS FOR SYSTEMS DYNAMICS FUTURE.

On balance, when all the elements are considered in the causal loops and the inevitable time lags are taken into account the long term prospects for Systems Dynamics appear very promising.

Examining Systems Dynamics as a new technology it appears to be still in the preliminary phase of development when major technological innovations are taking place, new applications are being discovered, the diffusion is limited and competition among its practitioners is scarce as their most important endeavour is to obtain recognition for the field. Systems Dynamics appears however to be quickly approaching the takeoff phase when major professional activity is likely to take place as it develops into a recognized field.

In support of this statement we observe the growing number of participants at Systems Dynamics conferences, the quality and variety of the tools available, the relative proliferation of formal courses and the type of problems to which it is currently being applied.

True a wide awareness about Systems Dynamics potential has yet to materialize but once it does, it appears likely to trigger inclusion of the subject in the curriculum of most formal training programs. This may be many years in the future but a long road towards widespread diffusion has been already covered since the first steps were taken by Jay Forrester and the first group of his students in the late 50's and early 60's in founding Systems Dynamics.

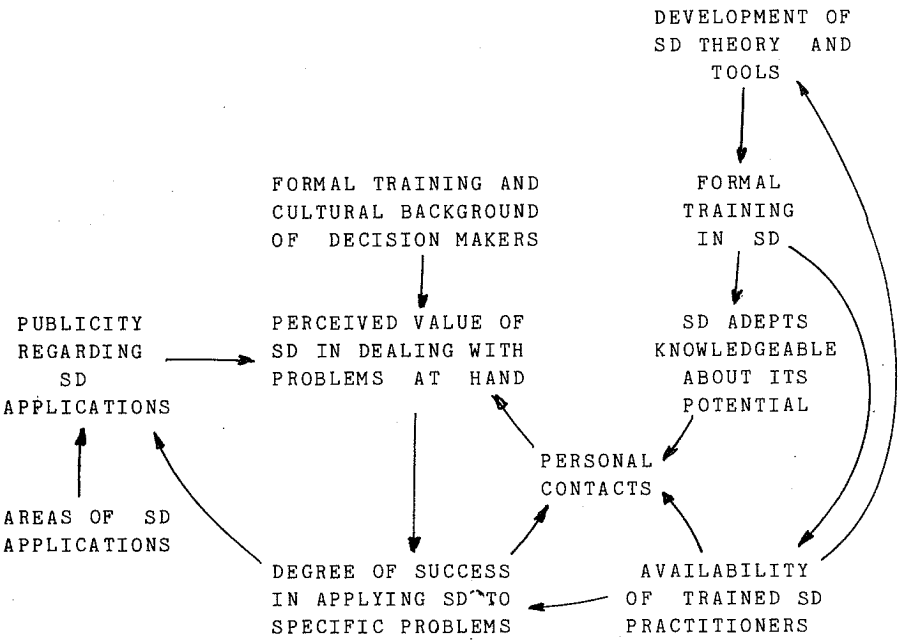

Fig. 1 Causal loop diagram in Systems Dynamics rate of diffusion.

If Systems Dynamics is viewed as a way for practical application of Cybernetics we may say that it has a history of almost 50 years over which the field has evolved from a complicated theoretical invention to a technology which, although not yet completely developed, can be widely taught and applied in numerous situations. The high potential of this field to influence dramatically our culture has been recognized very early and our current knowledge rather tends to confirm this initial judgment.

The potential for diffusion of Systems Dynamics has vastly increased with the vast adoption of microprocessor based computers and with the appearance of simulation tools usable on these machines. The increasing numbers of personal computers over the next decade is bound to reduce the computer illiteracy and this in turn is likely to reduce the resistance to computer simulation of real world systems by those who fear a technology they do not understand.

VI
ACTIONS NEEDED TO ACCELERATE SYSTEMS DYNAMICS DIFFUSION.

An examination of the causal loop diagram in Fig. 1 suggests that several actions need to be taken in order to promote faster rate of diffusion of Systems Dynamics. These actions may be grouped under the following headings:

1.- Development of Systems Dynamics theory.
2.- Development of better and more user friendly tools.
3.- Improvements in the Systems Dynamics training.
4.- Introduction of Systems Dynamics notions in a variety of studies.
5.- Undertaking of Systems Dynamics studies with high publicity potential.

1.- Development of Systems Dynamics Theory.

Several aspects of the Systems Dynamics theory need further development. These developments should refer to improvements in model conceptualization, analysis of behaviour of systems in which many different loops interact, pattern recognition, and possibly development of algorithms that guide the user towards policies resulting in the desired behaviour of the system.

The improvement of those aspects of theory that allow description of waves encompassing single events also appears desirable.

2.- Development of better and more user friendly Tools.

Both STELLA and PROFESSIONAL DYNAMO represent recent examples of advances in this area. In spite of the progress already made there is still a lot of ground to be covered. We may easily imagine tools that will help us in the process of conceptualization and tools that will automatically select the most adequate policies for governing our systems within predetermined boundaries.

We may also think of tools that will allow the use of Systems Dynamics in conjunction with artificial intelligence, with probabilistic simulation of systems that will interact with other algorithms (for example: optimization or selection of portions of a complex surface) that might be applied to some sections of the systems under study.

3.- Improvements in the Systems Dynamics Training Programs.

Familiarity with Systems Dynamics in terms of appreciating its potential is very desirable in general but not sufficient for model building. For broader successful applications the development of specific skills needed for model building and for use of models in complex environments is of crucial importance.

Training programs need to be clearly labelled as to their objectives. It is essential that those who attend them know whether they are only exposed to Systems Dynamics to become its illuminated promoter-users or whether they are ready to go out and build models.

It is necessary to train students for overcoming difficulties when they will want to use the models. They also must be shown the problems they will encounter when they will want to build models for use within complex organizations. Such teaching will avoid many false expectations and consequent frustrations. It may also avoid some failures which in the past probably have slowed down the rate of Systems Dynamics diffusion.

Students who will build models in addition to solid grounding in Systems Dynamics should probably be taught how to acquire knowledge about the situation they want to model and how to interact with experts, decision makers and other parties involved in the process of model building, testing and use.

Students who will only be exposed to Systems Dynamics to become its promoter-users within complex organizations should understand clearly the benefits they can obtain from using this approach. In addition they must know the barriers they will encounter within their own organization, how to overcome them and how to get good model builders to work productively with experts from their own organizations.

Selection of problems to which Systems Dynamics will be applied is very important in the early applications in any environment.

4.- Introduction of Systems Dynamics Notions in a Variety of Studies.

We have seen in Fig. 1 that formal training and cultural background of decision makers represents a major factor in evaluating the usefulness of the Systems Dynamics approach to the problems on hand.

In addition to being a technology Systems Dynamics is also extremely useful as a way of thinking about problems in almost any field. This means that simulation models need not be built in every situation but the understanding of cause effect interactions in long chains of events, of the delays involved, of the feedback loops and of the resulting behaviour can be applied on a very wide scale just like logic and mathematics. Therefore a lot is to be gained from its broad diffusion in the most varied types of studies.

5.- Undertaking of SD Studies with High Publicity Potential.

This item is listed here only for the sake of completeness. Systems Dynamics pioneers have always been searching for opportunities to do studies with publicity potential. They have treated problems of widespread public interest as attested to by the following titles: Limits to Growth (1), World Dynamics (2) The Persistent Poppy (3) Urban Dynamics (4).

In order for a study to have a high publicity potential the following conditions should be satisfied:

A.- The study should refer to a subject that commands widespread interest.

B.- The study should be sponsored by a group or organization having interest in the publication of results and both stature and influence to ensure wide diffusion of the study.

C.- The results should provide new insights and possibly be unexpected.

CONCLUSIONS.

Given the high potential usefulness of Systems Dynamics on the one hand and the complex requirements for its practical utilization on the other, the rate of its diffusion should probably not be judged to be slow, never mind the impatience of some of its prophets.

The conditions for its acceptance will have been created as computer literacy will grow with the wider acceptance of microprocessor based computers and as more people will become aware of the Systems Dynamics potential either through its wider presence in various study programs at high school and university level. in complementary company training programs, in general popularization courses or through literature and personal contacts.

At the same time further development of theory and of user friendly application tools will render the treatment of problems with Systems Dynamics more attractive from the point of view of costs (and risks of failure) and benefits.

Adequate training in model building using the Systems Dynamics approach will provide the skilled professionals indispensable for satisfactory applications.

As things look today all of the above conditions are evolving satisfactorily thus allowing to anticipate a brisk progress of Systems Dynamics in the future.

True there may be those who will argue that Artificial Intelligence represents the new technology that will evolve and substitute Systems Dynamics as time goes by. It would probably be more logical to conclude that future will offer an opportunity for a symbiosis between Systems Dynamics and Artificial Intelligence and it depends entirely upon the Systems Dynamics community's efforts in the direction of research whether their field will absorb the needed concepts from Artificial Intelligence in order to survive or whether it will become a branch of Artificial Intelligence.

REFERENCES

(1) Meadows, D.H., Meadows D.L., Randers J. and

Behrens III, W.W., (1972) I Limiti dello Sviluppo, Mondadori, Milano.
(2) Forrester. J.W. (1971) World Dynamics, Wright Allen Press, Cambridge, Massachusetts.
(3) Levin, G., Roberts, E.B. and Hirsch G.B., (1975) Ballinger: Cambridge, Massachusetts.
(4) Forrester. J.W. (1970) Urban Dynamics, M.I.T. Press, Cambridge. Massachusetts.