

DISCUSSION:

FURTHER DYNAMICS OF SYSTEM DYNAMICS

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ABSTRACT

This paper is essentially a reply to Willard Fey's challenge of how System Dynamics might be used to assist its own development. It builds on the basic ideas suggested by Fey for the representation of the field of System Dynamics as a human feedback system. Additional perspectives on the field are derived using a reformulation of the System Dynamics method and it is concluded that a more thorough understanding of the environment of the field is required as a prerequisite to further growth.

INTRODUCTION

Willard Fey's paper in the last edition of this Journal¹ and its subsequent derivative,² presented to the 1981 System Dynamics Conference, were based on the theme that the methods of System Dynamics ought to be applied to the analysis of problems within the field of System Dynamics itself. The main argument contained in these papers is basically that, after 25 years of existence, the achievements of System Dynamics are less than might be expected; for example relative to the achievements and impact of other disciplines over their first quarter century. More specifically, the questions posed were (i) why are there so few practitioners? (and why are they spread so thinly geographically?), (ii) why the image of System Dynamics is unclear? and (iii) why antagonism to the efforts of practitioners exists?; particularly in view of the recognised potential of the subject.

The challenge put to practitioners by Fey was to try to analyse these problems by using the methods of System Dynamics themselves. This is an important and difficult task and the first steps have been taken by Fey himself.² Interestingly this type of introverted approach is also being used in other more established disciplines; in the field of Operational Research this is referred to as O.R. squared.

This challenge has been taken up by the System Dynamics Research Group at Bradford University Management Centre and the contribution reported here stems from the combined efforts of the Group, although its interpretation and development is the responsibility of the author.

THE FEY MODEL

Firstly, it is important to recognise that the steps already

taken are significant. Fey suggests that the field of System Dynamics is in essence a human feedback system, which exhibits unacceptable low growth for its important variables, and which should be amenable to structural and policy redesign to improve performance. His influence diagram² is reproduced in Figure 1 as a starting point for discussion. This contains many of the basic, aggregated elements and processes that we might expect to be relevant to a study of the development and growth of the field, and to the trained analysts is largely self-explanatory. The overall loop pattern centres on the quantity and quality of practitioners, whose efforts and guidance increase the quantity and quality of work, the impact of which is to generate increased demand and hence facilitate further recruitment of students to train as practitioners.

As it stands, however, the model is essentially a classical growth representation and as such it could equally well depict the mode of development of any discipline of knowledge. Further, since it assumes that all practitioners are 'home grown' it is perhaps more appropriate to the advanced stage of development of a mature subject than the early days of a new subject. In tailoring it to the System Dynamics field there is a need to develop additional perspectives capable of recognizing the current and unique characteristics of that field.

The generation of such alternative perspectives on a problem is of course one of the more difficult areas of model conceptualization and the approach used here is based on a recent general reformulation of the System Dynamics method developed by the author. This will be briefly explained in the next section as a prelude to developing further insights to the problems posed.

THE GENERATION OF ALTERNATIVE PERSPECTIVES

It is of interest to record here that one of the major reasons why it was felt necessary to reformulate the System Dynamics method was to try to improve the impact of System Dynamics on other related fields of system enquiry. Basically, it was felt that current attempts to convey the method tended to mix the system description and model formulation modes of the subject too much and that there was a need to clearly separate these functions and provide more step by step

guidance. The philosophy of this development has been discussed and the detailed steps involved explained elsewhere.^{3,4,5} However, the steps of the method are summarized in the Appendix (I) to this paper.

Essentially, the method is concerned with assisting the development of system description, starting from identified key variables associated with the symptoms of a problem. The main contribution of the approach is the subsequent focus of attention on defining the physical resources and the relevant states of these resources, which are associated with the key variables. This is based on the recognition of the fact that the fundamental process in any natural or managed system is that of converting resources between alternative states, and that the power of System Dynamics lies in its ability to model the alternative ways in which conversion can take place. Obviously the resource states defined in this way are the levels of the system, and the resource conversion rates are the rates of the system. Hence the method forces early recognition of basic variable types. Further, the method tries to distinguish between the natural, behavioural and human control mechanisms, which determine resource conversion rates. The procedure is to generate a model in terms of simple modules, which are progressively intermeshed as other problems are recognised and further resources and states incorporated. Having built a model up in this way it is possible to simplify its linkages and hence assist in the difficult process of defining alternative dynamic hypotheses across resource types which might explain the behaviour of the system. The derived qualitative model may then be analysed as such or developed into a full simulation model.

ENHANCEMENT OF THE FEY MODEL

The key variables and resources within the System Dynamics Field have been clearly identified by Fey and given earlier in the outline of that model. By applying the method of the previous section to this problem it was felt, however, that additional resource states could usefully be incorporated in

Resources	States		
People	students	teachers	practitioners
Knowledge	cumulative applications work	cumulative research work	total perceived work

Figure 2. Resources and States in the Fey Model

the Fey model. Figure 2 presents the physical resources and states inherent in the latter; that is two resources each having three states. Figure 3 presents similar information derived in this study; that is the same two resources but with alternative relevant states.

The main contribution of Figure 3 is that it identifies people both inside and outside the field. Those inside the field are divided into active users and developers of System Dynamics, where industrialists perhaps make up the bulk of the first category and academics are present in both categories. Those outside the field consist of people either using other methods of system enquiry or no system thinking at all and are split

Resources	States					
People	Active System Dynamics users	Active System Dynamics developers	People hostile to System Dynamics	People neutral to System Dynamics	People benevolent to System Dynamics	Potential System Dynamics users and developers
Knowledge	cumulative applications work	cumulative research work	disseminated work	accepted work	total perceived work	

Figure 3. Alternative States for the Resources in the Fey Model

into hostile, neutral and benevolent sets, since each category might require alternative methods of 'converting'. These are all potential System Dynamics activists and the categories could be replicated for potential users and developers.

The states associated with the knowledge resource are very similar to those of Feys but suggest that it might be useful to recognise the intermediate states of disseminated and accepted work.

A MARK II MODEL OF THE SYSTEM DYNAMICS FIELD

Figure 4 presents a Mark II Influence Diagram for the System Dynamics Field, incorporating some of the resource states of the previous section. This follows the convention⁶ of denoting physical resource states by boxes, physical flows by solid lines and behaviour/information/control links by dotted lines. The heavy solid line separates the variables within the field from those outside the field.

A qualitative analysis of this diagram indicates, as in the Fey model, that a profusion of positive loops exist within the field, but that overall growth is heavily influenced by factors and effects outside the field. The diagram recognises that System Dynamics is not at the classical advanced stage of many other disciplines, where large numbers of people are trained specifically in the subject; and that active system dynamics users and developers must at present be mainly recruited from outside the field by active promotion. It is suggested that recruits must initially be generated from potential users who are already benevolent to the field, primarily through the medium of short courses. It is reasonably true to say that such recruitment is being achieved and is being assisted by the increasing relevance of the System Dynamics paradigm to the complexities of contemporary life.

The conversion of potential users from a hostile to a neutral stance, and from a neutral to a benevolent stance is a much slower process, dependent on how carefully we collaborate and identify potential markets for System Dynamics within these categories. This in turn implies careful co-ordinated, dissemination and directing of publications to the relevant audiences. The identification of markets and the mode of publication are considered to be important additional key variables in the system. Irrespective of how hostility has occurred in the past there is a clear need to ensure that our current and future impact is sufficiently great to overcome this. If it isn't, then the positively degenerate loop in the top left of diagram 4, reinforced by its hysteresis effect, will grow and undermine our ability to influence the more amenable sectors outside the field. One very observable consequence of

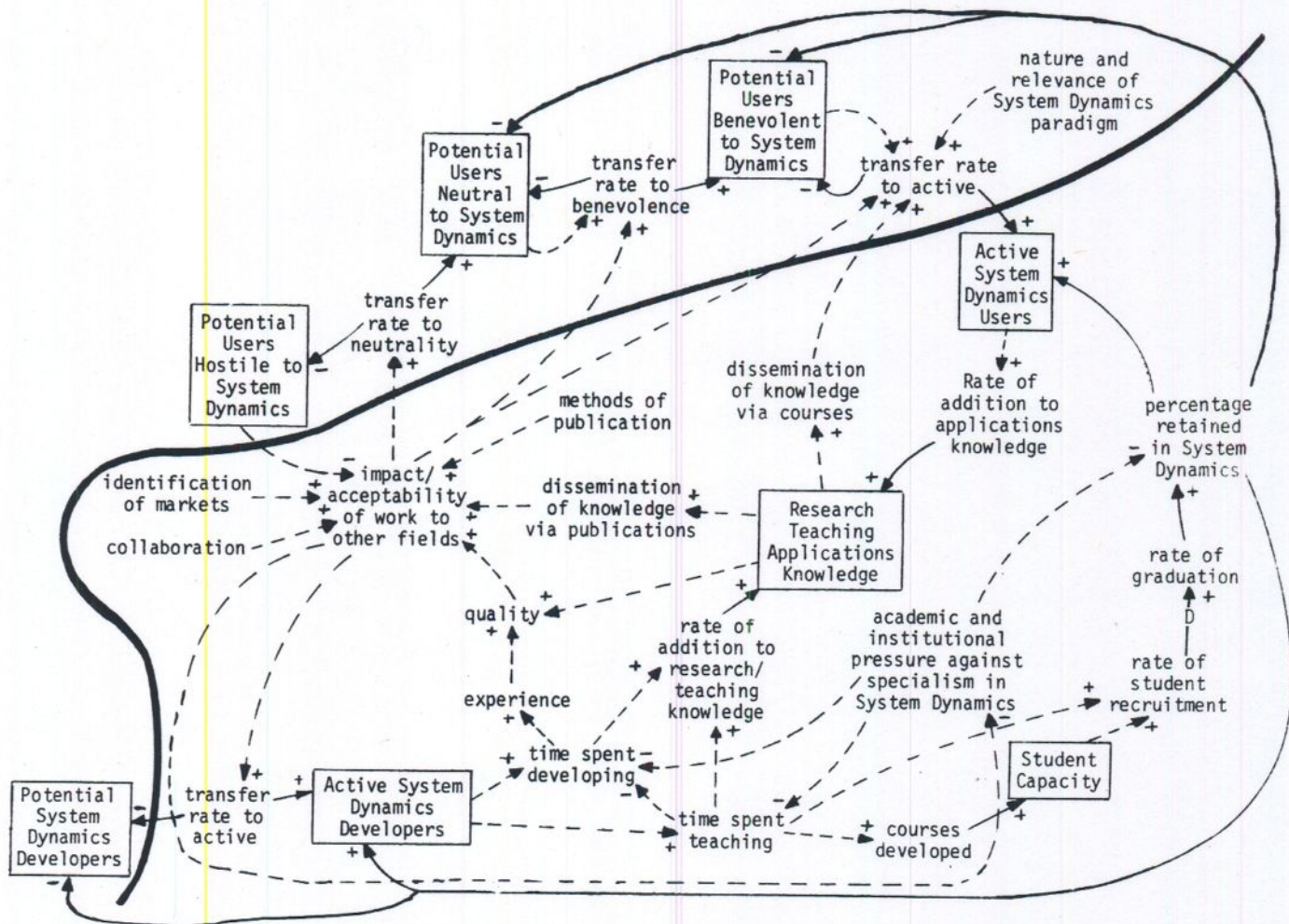


Figure 4. A Mark II Influence Diagram for the System Dynamics Field

an uncertain impact due to hostile influences, which is shown in Figure 4, is the effect this has in producing academic and institutional pressure against the specialism of individuals in System Dynamics. Many academic practitioners are all too often made very much aware of the need to balance their teaching across other areas, and the dilution effect which this has on their efforts. This attitude also reinforces the perception of System Dynamics as just another problem solving or management technique rather than developing the image that it is a subject in its own right.

One might consider this analysis to be a self fulfilling prophecy, since it has been stated that the methods used were derived from a need to help improve the transparency of the subject, and that their application has indicated a need to improve the communication and impact of System Dynamics. This is true to the extent that the methods used were derived to assist in making an impact outside the subject, but essentially on one type of market only; that is the General Systems and Operational Research Field. Other sectors of our potential market need to be defined and perhaps further

appropriate reformulations would be one way of influencing these. It is possible to see for example that a slightly more specific version of the rules of Appendix I could be built up for assisting model formulation in the corporate planning field.

CONCLUSIONS

There is much to be gained by applying System Dynamics methods to the subject itself. In view of the analysis presented here it is suggested that, apart from concentrating on renewed efforts within the field of System Dynamics, practitioners must identify and examine that part of the environment of the field which can best be influenced. This examination must be thorough and accurate, since it must be recognised that it is from these sources that current recruitment to System Dynamics must originate; at least until we are in a position internally to vastly increase our student output.

It is hoped that the analysis attempted here will be built on by others and the theme of Will Fey's challenge carried much further.

APPENDIX I

SUMMARY OF THE APPROACH

1. Recognise the key variables giving rise to the observed symptoms of concern and to the need for enquiry.
2. Identify some of the initial system resources associated with the key variables.
3. Identify some of the initial states (levels) of each resource to be used.
4. Construct physical flow modules associated with each state of each resource, containing the physical processes or rates which affect these. (A module must contain at least one resource state and one rate).
5. If more than one state of a resource is involved cascade flow modules together to produce a chain of resource conversion or transfer.
6. For each module, or set of cascaded modules, identify the *intra* module behavioural information and control (policies) links by which the levels affect the rates.
7. Identify similar behaviour, information and control links between modules of different resource types. For complex situations this should be carried out for small groups of resources at a time within a defined theme and the resultant diagrams reduced to produce the simplest representation possible, consistent with relating the key variables of the investigation.
8. Identify any new states of existing resources, or new resources, or new key variables, and add these to those recognised at 1 and 2. Reiterate if necessary.
9. Carry out a qualitative analysis of the overall diagram to identify:
 - (i) further problems, in addition to those recognised in step 1, associated with the system;
 - (ii) specific relationships in the system which need further analysis by specific techniques;
 - (iii) the major controllable variables (and, in multiple ownership systems, the system actors responsible for each);
 - (iv) the general systemic impact of changes to the controllable variables;
 - (v) the vulnerability of the system to changes in uncontrollable variables;
 - (vi) alternative groups of compromise changes which might lead to improvements in the system performance.

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