Observing the process: reflections on issue selection and model conceptualisation in a case study concerning the dynamics of programmer recruitment

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ABSTRACT

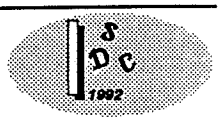
When performing interventions with practising managers, questions arise concerning the approach which should be used to generate and select the issues to study without biasing the process towards a system dynamics framework. This paper describes a project in which care was taken to observe the stages of the process to facilitate reflection on the project's development. The case involved two managers from an information technology department and evolved into a study of the dynamics of their new programmer recruitment policy. Early use of the 'magnetic hexagon' approach allowed articulation of the issues and focussing of interest on one issue. Policy structure diagraming was used to elicit a model and computer implementation and scenario generation followed naturally. The paper closes by recording the insights gained by the clients and by proposing some general lessons on techniques for structuring the early stages of consultancy projects.

§1 Setting The Context

This paper records the application of system dynamics modelling techniques to a problem of staff headcount planning. The modelling process was facilitated by consultants but owned and directed by the problem owners. This paper describes first the commercial background to the study and then moves on to the project stages. Of particular interest in this case study are the general problem structuring procedures used for the first two stages (§§ 2 and 3). These assisted a divergent discussion which articulated the clients many issues and went on to support a focussing of their interest on a specific issue. The case account closes (§4) with a record of the use of policy structure diagrams as the path to a functioning computer model and the experiments made with that model. However, this material is kept brief, partially due to space constraints but also because the burden of interest to the system dynamics community lies in the earlier stages of the case. The final section (§5) comments on the commercial consequences and draws some general methodological lessons.

The work was facilitated by two consultants from the Business Consultancy Department of Shell International Petroleum, based in London. This group had worked for the Group Planning Department on de Geus' (1988) 'Planning As Learning' initiative which involved the use of systems dynamics model-building as an approach to enhance managerial learning. By the time this project took place, the consultancy group had brought the tool into its own repertoire and extended the facilitated consultancy approach to cover 'softer' OR techniques, referring to the approach as 'Modelling as Learning' (see Lane (1992)). All consultancy work was charged out on a daily basis, enhancing the need to offer a quality service. For this reason the consultants were taking a total quality approach to projects, beginning to be interested in the general techniques which had to be used. Stephen Watson (1988) has indicated that in the field of decision support, it is an open question as to whether a methodology is transferable or simply the *modus operandi* of a particular, gifted individual. In order to apply the ideas of total quality, there was a need to find methods which were transferable so that they could be used repeatedly and by a range of staff. The study described here was approached with this in mind and was observed and recorded in a self-conscious way in order to observe the constituent parts of the 'Modelling as Learning' approach. Additionally, the standard approach of system dynamics formulation had been found rapidly to focus the discussion on issues which had a time-evolutionary quality. It was felt that this could lead to unsuitably directed analysis, so the department had an interest in continuing to experiment with more general problem formulation techniques.

The two clients worked for the Head Offices of a Shell company in a European country - call it 'Ruritania'. They came from a department which was responsible for Human Resource Planning for the computing and information technology needs of that country. This entailed staff recruitment and placement as well as training in response to rapid technology changes. The clients' responsibilities



embraced more than one thousand staff, from newly recruited computer programmers to senior IT strategists. One client was the head of this planning department, the other the assistant. These clients approached the consultancy department because they had a wide range of issues that they were trying to deal with and felt that external support could be valuable. Also, they had heard of the 'Modelling as Learning' approach and thought that it would be interesting to test what it could do for them. This latter consideration meant that they were open to new ideas but were working on a restricted budget.

The approach involved working with the clients during three meetings in what Richmond (1987) has called an 'intensive strategic forum'. In the next three sections the activities of this project are grouped into 'stages', each associated with one of those three meetings. Activities taking place in the meetings are indicated by •, those which were preparatory for that meeting, or followed directly on from it, by Δ.

§2 Stage I - Getting An Overview

Activities for this stage were:

- • Divergent Issue Generation using Coloured Thinking Hats
- • Recording with Magnetic Hexagons
- • Feedback of coloured hexagon diagrams
- Δ Extraction of main issues diagram

The consultancy work for this project was undertaken by a senior - the author - and a junior in training. A clear need of the clients was to cope with the large number of issues which they felt confronted them, whilst the consultants rapidly needed to find out about the human resource planning department and so master the context of the work. In response to these two needs the consultants had prepared for a divergent process based on the Coloured Thinking Hats approach of de Bono (1985). This involves taking a series of view-points on a problem using different colours as focus points or mantras, and then recording the insights. For example, concentrating on the positive, advantageous aspects of a situation and recording them as 'yellow ideas'. The purpose is to free those involved from ingrained patterns of thought; to encourage pessimists to also think positively, to encourage staff lost in detail to see the broad view and so forth. To this end the consultants had prepared five questions for the clients:

What are the purposes/goals of your department?	Purple	Vision
What are the things that your department does not do so well?	Black	Criticism
What are the good things in your department?	Yellow	Approbation
How might you wish to change what your department does?	Green	Creativity/Innovation
If you changed your department, what would be the success criteria?	Brown	Measurement

At the first meeting about 2 1/2 hours were spent on a divergent discussion of these five questions, each having its own distinct period of attention of some 20 minutes with later thoughts being labelled with the colour which the clients felt appropriate.

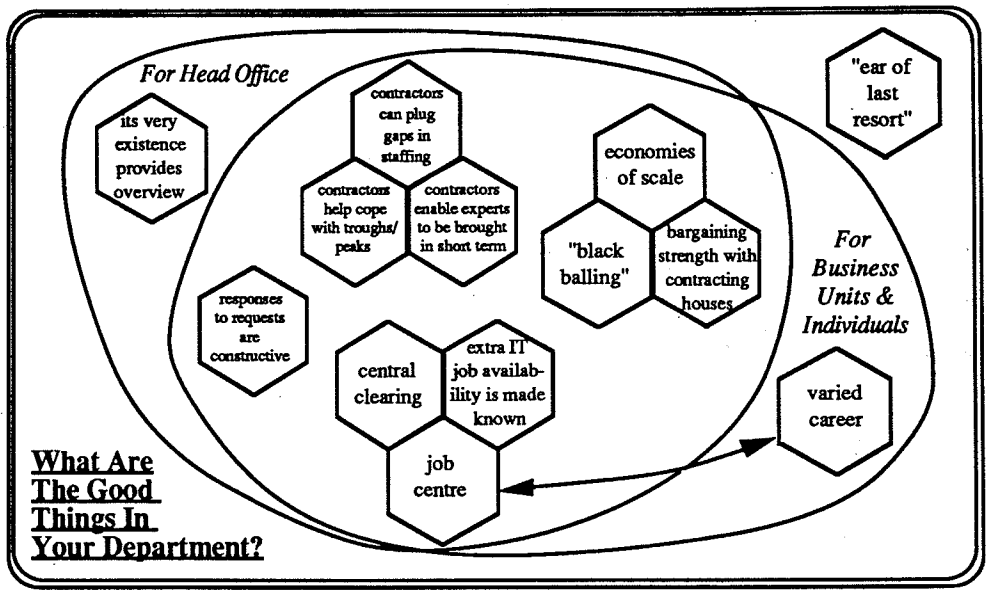
Although standard note taking has been used with success to begin a system dynamics study (see Morecroft et al. (1991)), it is not only non-involving for the client but is, as Eden and Sims (1981) state, "dependent upon a language structure that can only be presented sequentially". These limitations were tackled by the use of the 'magnetic hexagon' technique (see Hodgson (1992)). This approach uses the simple device of plastic hexagonal shapes upon which brief statements of ideas can be written before fixing them to boards via their magnetic backs. The hexagons are wipe clean and come in various colours[1] and sizes from 2.5 to 7.5cm; 2.5cm ones were used here. They are placed openly on a board so that all participants can observe the evolving record of the debate. Their magnetic attachment means that different arrangements, or 'clusters', of hexagons can quickly be created thus representing associations of thoughts and issues. Such hexagon diagrams can be viewed non-sequentially, in a style reminiscent of the way that one's attention may wander across a painting. The openness of this approach, combined with the tangible and spatial representation of knowledge allows participants to build on elicited ideas, trigger new thoughts and also see gaps in the associations of ideas.

The different coloured hexagons which are available are particularly useful when de Bono's approach is being employed. Each period of 'coloured thinking' was framed and encouraged by using particular coloured hexagons. The hexagons were placed on portable A3-sized boards which could be seen by the four participants and used to trigger new thoughts.

[1] The makers of the hexagons have extended de Bono's original six colours to sixteen. However, it has been observed that this colour code is frequently too large for clients to remember and use effectively.

By the end of this meeting five hexagon diagrams had been created. The clients felt that they had introduced their most important concerns and that the consultants had understood them. Straight after the meeting the consultants photocopied the boards so that copies could be given to the clients as a record of the meeting. A copy of one of the original diagrams is shown in Figure 1.

Figure 1. Example of output from the 'coloured thinking hats' sessions with the clients in the first meeting: the magnetic hexagon model from the 'yellow thinking' session.



After the meeting the two consultants spent one work day summarising the boards into a 'main issues diagram', building the various 'coloured' responses into three clusters of concerns (see Figure 2). 'Matching Careers to Staff Need' embraced the dual difficulties of preparing staff to cope with rapid and unpredictable innovations in IT and developing them to manage a business requiring detailed technological knowledge within a company with a strong 'generalist' culture. 'Time Effects' expressed the clients concerns regarding their handling of staff numbers at each level of job whilst 'Centre/Business Units Issues' involved the relationship between the head office in the country concerned and the regional offices (see next section). Photocopies of this diagram, along with photocopies of the five coloured hexagon diagrams, were sent to the client with a covering note some two weeks after the first meeting.

§3 Stage II - Issue Selection & Model Elicitation

The activities for this stage were:

- Δ Preparatory modelling of 'Medler' issue
- Presentation and discussion of main issues diagram
- Selection of issue to study
- Elicitation of dynamic hypothesis
- Elicitation of policy structure diagram

In preparation for the second meeting the two consultants tried to out-guess the clients by doing preliminary work on what seemed like the most likely topic for further analysis. The purpose was to make best use of the limited time available by thinking beforehand about the routes that the clients could take. From the first meeting the 'Medler issue' seemed to be of greatest interest.

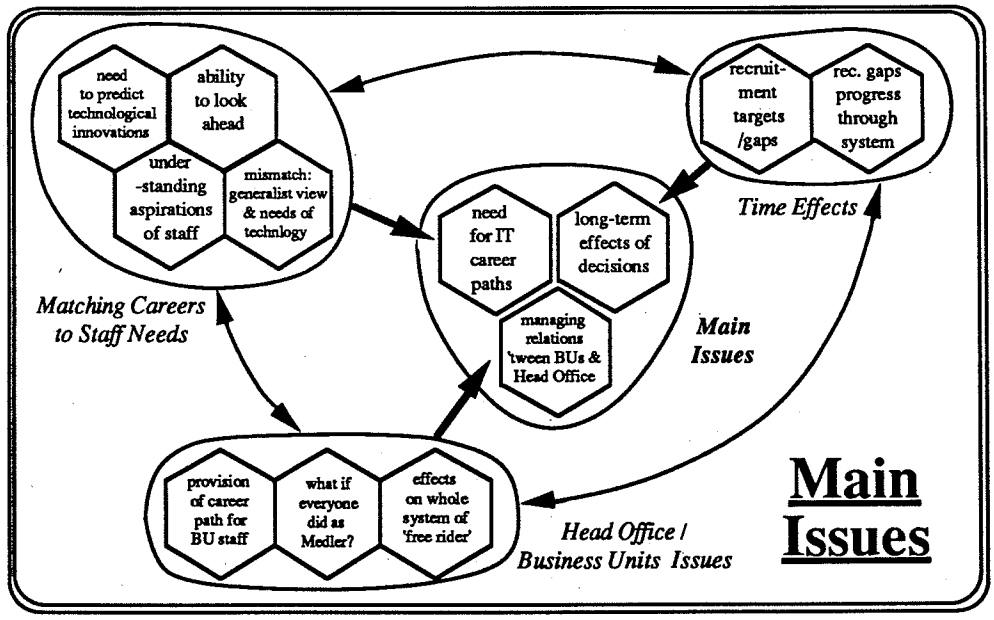
Medler (an alias) was a city which contained a regional office. The business units based in such regions of Ruritania had an arrangement with head office. Head office would recruit and send out young (college graduate equivalent) staff to take up junior computer programmer posts for some 2 years in order to get basic experience and training. They would then return to head office for more senior posts and advanced

training. The Human Resource Planners could, therefore, recruit staff by offering them a 'real job' in a region before progressing them to middle management and beyond. The regions' *quid pro quo* for looking after raw recruits was that they got access to a pool of experienced, 30+, IT managers who could lead regional marketing departments using the strategic and international experience gained at head office.

In Medler, the local manager had opted out: in the last month a trained programmer had been recruited directly into the region in order to get a complex piece of work done rapidly. The Human Resource Planners were concerned that the recruit could not have a full career path in Shell without taking a job in Ruritania head office but that this would look like giving a 'free ride' to the Medler region since they had not had the training burden. Additional questions concerned Medler's right to draw on experienced staff and whether the whole system might be in danger of breaking down if more regions acted in this way.

This issue seemed the most likely candidate for further study because of its importance and immediacy. Another workday of effort was therefore spent by the consultants on pondering this problem. Among the various pathways which emerged from a brain-storming session were: a spreadsheet model to demonstrate the cost advantages of the current system to Shell Ruritania as a whole; comparative career plan profiles for staff brought in under the old and new systems described in five year segments and, finally, various means of convening forums in which staff from head office could debate the issue with staff from the regions.

Figure 2. The clients' main issues, presented using a magnetic hexagon model. Small changes have been made for reasons of confidentiality but the figure is very close to the one used in the project.



At the second meeting - about three weeks after the first - the clients were asked for their reaction to the main issues diagram (figure 2). They responded positively saying that, in association with the original 'coloured' diagrams, it recorded their views very well. They said that it was a useful way of expressing the different issues which they faced, enabling them to see the inter-relationships whilst removing the feeling that they were fighting an overwhelming muddle of problems, like a multi-headed hydra.

The first hour of this meeting was spent discussing the clients issues using the diagram for support. The cluster 'Matching Careers to Staff Needs' was quickly rejected as an area for further study. The issues were very complex, concerning technology projection, demographics, career planning, business strategy and hierarchies of human needs. The clients felt that they wanted a better understanding of what analytical techniques could do generally before taking on such a complex problem.

On the Medler issue there was a long discussion. The clients appreciated the consultants' proposals and the preparatory work proved very useful in accelerating the discussion over what approach to take. However, to the surprise of the consultants the clients finally chose to focus on the remaining issue cluster for more work. Their reasoning was that the Medler opting-out action was, after much telephone activity, being seen to be more localised than had first been feared. The local manager had wanted a specific and particularly important assignment completed rapidly; he/she showed no sign of repeating the action and canvassing of other regional managers had shown that, with the assurance of no repetition, they would not have objections to Medler's continuing to draw on the central resource. As a variant on Harold Wilson's comment, "a week is a long time in politics", this seemed quite convincing! On being asked whether the first meeting had prompted the clients to take action and begin to pursue this subject, they could not give a clear answer. The question remains whether the preparatory time spent by the consultants was wasted. On a general level it certainly made the consultants feel that they had come to grips with some of their clients' real problems, giving them confidence to cope with any new ones. Specifically, it allowed the Medler debate to proceed very rapidly, the area to be rejected and the team to turn their attention to the issue around which the remainder of the project was based: the dynamics of programmer recruitment.

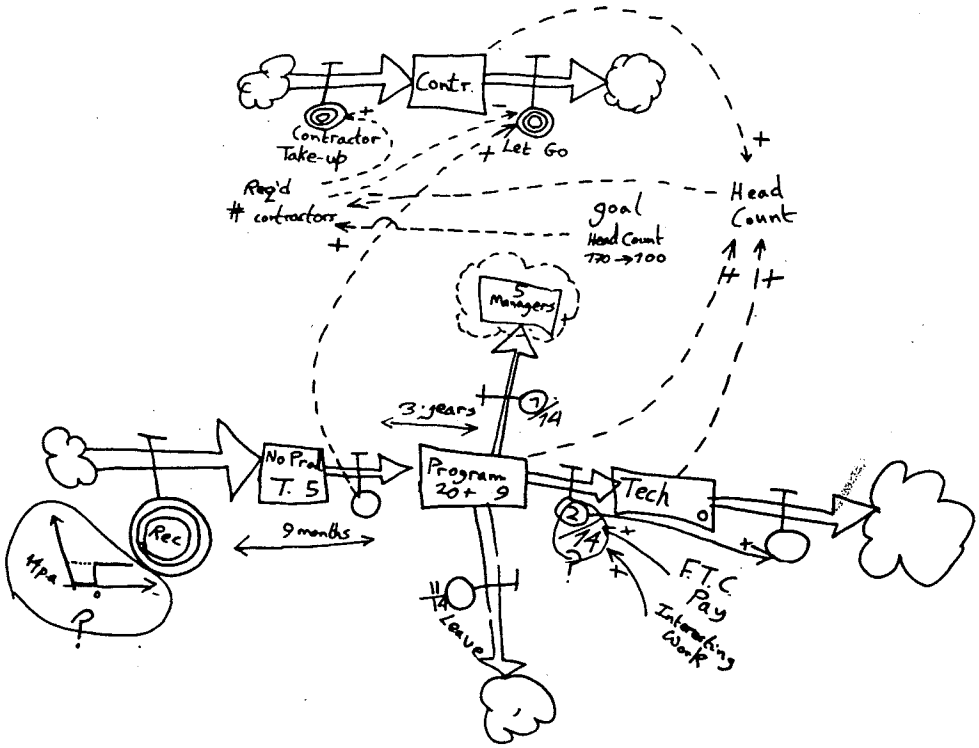
In the remaining two hours of the second meeting the clients gave more detail on the Time Effects cluster. Shell Ruritania had about 170 computer programmers at that time. More than 80% were 'contractors', staff who were brought in for a specific job on rolling one year contracts and whose job histories consisted of assignments with many companies. Such staff were paid a risk premium for their services to compensate for the job insecurity and, being dedicated programmers, tended to be technically very proficient. They were readily recognisable as those who sat around the offices wearing jumpers. Only 18% of the programmers were Shell 'full time staff', that is, staff who could be expected to stay on past their current job and advance to managerial and commercial posts in the organisation. These were equally readily recognisable as those who sat at computer terminals but wore silk ties. This dearth was attributed to a college-based perception that programming was both uninteresting and very difficult.

This situation had been deemed intolerable by the head of the IT department for two reasons. Firstly, Shell offered contractors good training and experience on the most advanced technology, a situation which encouraged them to work for one or two years and then trade upwards to dedicated IT companies. The high percentage of contractors made the consequent loss of experience and diminution of commercial confidentiality unacceptable. Secondly, the number of programmers had grown continually in the previous five years with no sign of the reductions supposedly afforded by higher level languages and user-friendly packages. Two decisions had been taken to correct this situation. Programmer numbers were to be reduced to 100 over the next five years; it was hoped that this would yield efficiencies which were hidden in the system. Additionally, a new cadre of programmers had been created, known, rather confusingly, as 'Shell fixed term contractors' (FTCs hereafter). The goal was to have some 60% of the programmers in this cadre in five years time since this would give a suitable mix of stability (of experience) and responsiveness (if rapid staff reductions were required). This gave two clear requirements for the behaviour of the programmer system; two dynamic hypotheses on desired behaviour.

The debate moved on to how the clients intended to make their dynamic hypothesis come about. The FTCs would have a more structured career start. They would be recruited for a training period followed by a fixed contractual period of work of three years. The training would last about nine months and would ease graduates into the work. Careful selection would ensure, the clients insisted, that all trainees would pass the training and then go on to be programmers. Their work would be varied to keep them interested in a Shell career. However, many would leave at the end of their contract, some would become senior programmers ('Technicians'), a very few would move into a management stream. The number of contractors would be adjusted to reach the headcount goal; more contractors would be hired from the market or they would be given the one month's notice specified in their contracts if reduction was needed. The clients believed that a recruitment rate per annum of 14 into the FTC cadre would achieve the required goals.

As the clients described the ageing chain and control system which was at the heart of the recruitment system, the consultants began to represent the structure on a large white board. Policy structure diagraming (Morecroft (1982) & (1983)) was used as the information consisted more of structural detail than descriptions of feedback loops. Stocks and flows were identified by looking for accumulation effect

Figure 3. Policy structure diagram for the clients' ideas on the programmer recruitment issue, as elicited during the second meeting.



or instantaneous response (cf. Forrester (1968a)). The stock and flow symbols of system dynamics, as well as the decision symbol, were introduced but without explicit definition; the context in which they were used allowed to clients to become familiar with the iconography very quickly. Parameters and initial values were noted down along with the recruitment rate (considered a fixed input by the clients) and the feedback loops (see Figure 3). Although the clients could not, in this case, be encouraged to draw parts of the diagram themselves, their responses, comments and corrections demonstrated that they had a clear understanding of the ideas represented in the model.

The meeting closed with the consultants explaining that for the third and final meeting the team should work on creating a functioning computer model of the diagram in order to see whether the system structure was capable of supporting the required behaviour. Additionally, the white board was removed in order to have it photographed.

§4 Stage III - Model Preparation & Scenario Generation

The activities for this stage were:

- Δ Transfer of policy structure diagram into STELLA
- Δ Building of experimental model
- • Presentation and completion of model
- • Scenarios: policy testing and insight generation

The first act after the meeting was to convert the policy structure diagram of Figure 3 into a STELLA model (see Richmond et al. (1987)). This was a straightforward process. The only point of interest is the separation of flows for the contractors stock. Although mathematically an outflow can be represented by a single inflow which can change sign, the clients clearly felt that these were different processes.

'Contractor_Take_Up' implied going to a market to recruit, a process which would be influenced by many factors, external and internal to Shell, whereas the outflow was straightforward; 'Let_Go' represented the company terminating contracts and so just lagged the difference between 'Contractors' and 'Req'd_#_Contractors' by the contractually specified one month. A simple piece of Abelian logic allowed the model to represent the clients' understanding of these processes.

Although the model had not been fully specified during meeting two, the known parameters were applied and reasonable guesses made for the remainder. This produced an 'experimental' model which could be run, allowing the consultants to specify useful graphical and tabular output as well as understanding the dynamics of the system. Preserving the output formats, the estimated parameters were removed. Notes were made of their locations along with notes on questionable values and areas of structure which needed confirmation or further work. The opportunity was also taken to write explanatory comments at all points in the model to encourage client exploration later. Total effort for the modelling was 2 days.

At the third meeting - three days after the second - the project team was aware that some form of interim results was required as the clients' budget would have ended. However, this was not difficult to achieve. The white board with Figure 3 was displayed and compared with a large printout of the STELLA diagram. In this way the clients were able to transfer their approval from the diagram which they had seen drawn, onto the interface of a computer model[2]. Only once they had achieved this were the clients asked to look at a very much smaller image on a computer screen. The diagram was displayed and the clients were encouraged to tour the structure and examine the algebra. The consultants directed the discussion so that any unknown parameters were elicited and uncertain parts of the model clarified or corrected. For example, the clients counted Technicians as Shell staff but also had them moving on after three years.

	Recruitment Rate p.a.	Technician Fraction	Wastage Fraction	Headcount Year 5	Company % Year 5	Company % Year 10
Base	14	2/14	11/14	101	42	47
A	22	2/14	11/14	101	61	72
B	14	6/14	7/14	101	53	58
C	14,17,22,<u>25</u>,24,14,17..	2/14	11/14	101	60	59
D	14,16,19,<u>20</u>,19,10,14..	6/14	7/14	101	60	60
E	14,14,14,15,16,<u>17,17</u>,12,14..	6/14	7/14	101	(Year 7: 60)	60

Table 1. Data on scenarios; note the invariance of 'Headcount'. Where recruitment rate varies, it is tabulated at yearly intervals and dots .. indicate that the previous value is held to the simulation end. The maximum value in each scenario is underlined.

Runs of the model began with the Base Case scenario, all parameters taking the clients' initial values (see Table 1 above for details of all scenarios). The headcount goal was reached but the Shell FTC percentage was not. Even if the model was run for ten years, <u>this</u> target was not achieved. The clients then studied the model to understand why this was. Very quickly, the consultants were able to help the clients to see that the headcount goal would always be achieved: because the reduction was so rapid that contractors were always let go, never recruited; since this process was controlled by a feedback loop, and the lag was only one month, headcount closely tracked goal headcount. In contrast, the specified model had no control loop for fulfilling the Shell percentage goal. The input rate of 14 recruits per year now

[2] Now that LCD panel technologies have improved, the recommendation would be to omit the photocopy and contract the three stage approval transfer process described here to a two stage one: white board diagram to projected computer diagram

seemed arbitrary and only luck would have got the system to its second goal. The clients then began a series of policy experiments in order to gain further insight into their system. Since the structure of the system is essentially an embellishment of a simple inventory model, only brief comment will be given on these experiments.

Scenarios A and B were attempts to reach both goals by re-setting the policy variables. In Scenario A recruitment was raised to a higher, though still constant value. An annual rate of 22, an increase of 57% on the base value, was found to work, though the system overshot the goal after five years. Scenario B used an increase in the proportion of FTCs staying on after three years - 'Technician Fraction'. The ratio leaving Shell - 'Wastage Fraction' - was lowered appropriately. Obtaining reasonable values here required a discussion about salaries, training packages and managerial responsibility. The clients did not require that any of these effects be modeled; instead they used their understanding of what the policy levers meant as a spring-board to bring other parts of their knowledge to bear, using 'mental simulation' to get a final value. The system reached the goal but again overshot however, no increase over the base value of recruitment rate was needed.

Scenarios C and D involved varying over time the policy variable of FTC recruitment rate to ensure that the system both achieved the dual goals and remained there. Rather than specify a computer-based feedback loop to achieve this, the clients elected the loop of model -> screen -> eye -> brain -> hand -> model re-run. Quite simply, they enjoyed trying different numbers and observing the whole run to see if it would work. In the process they came to understand the effects of the training lag on the behaviour of the system, an effect which many managers have been observed to understand only poorly, see for example Senge (1990) and Sterman (1989). Standard inventory gap closure profiles were found, the base value of Technician Fraction needing a peak value 79% above base whilst the highest realistic value needed an increase of only 43% (scenarios C and D, respectively).

The final scenario E was an attempt to see the change in recruitment rate needed if the Shell percentage goal was deferred by two years to year seven and an incentive package was put in place to retain more FTCs. Peak recruitment was 21% above base value.

It should be noted that all of these observations and experiments were made whilst the clients were quite comfortably running the model themselves, putting in data using the mouse and keyboard and discussing and interpreting graphical and numerical output.

This final meeting ended after three hours, though this fact surprised the clients when it was pointed out to them - they had been engrossed in the model! The consultants agreed to write a 'Project Account' - not a project report, which might suggest that the goal of the project was a report containing recommendations, but a record of the steps taken, materials generated and insights gained, so that a reader might get a sense of what a project such as this might have to offer. The complete range of benefits of the study became clear only in the weeks following this meeting and is discussed in the final section.

§5 Consequences and Lessons

The consequences of the project resulted both from activities in the model building stages and from some activities occurring afterwards. For the two clients involved in the process there were considerable gains in understanding their problem system and these were proffered by the clients in an additional discussion which occurred after the third meeting. The gains are stated very briefly here. Firstly, they came to believe that their recruitment system would not deliver the dual goals required. They came to understand the role that feedback control has to play in this type of result; a loop existed to achieve the headcount goal, none existed to supply the Shell percentage goal. On finding a recruitment rate which achieved the goals, they observed overshoot, reinforcing the role of feedback but, as one commented at the time, demonstrating that, "moving a system to a new goal and then getting it to stay there are two very different things!" The clients explored the type of rate functions needed to achieve this with scenarios C, D and E. They were prompted to think further about the use of incentives to reduce wastage so as to achieve their goals, broadening their attention from increasing system input to decreasing system output.

Additional insight came a little later via a circuitous route. As an experiment in new 'microworlds' technology, the author worked with Matthew Byrne of the Business Consultancy Department to transfer this model into MicroWorld Creator package (Diehl (1990)). A member of one of Shell's Group-wide recruitment departments experimented with this model to much the same effect as the clients. However, he felt strongly that the variations in recruitment rates resulting from scenarios C and D would not be acceptable. His reasoning was that Shell recruitment professionals build up long term relationships with careers officers in colleges/universities so that mutual needs are understood. He was very unhappy with

the type of year on year changes suggested by some of the model runs, claiming that recruitment needs which varied so much would leave careers officers confused and wary of Shell, a situation which could not be risked. This observation was conveyed to the two original clients and was incorporated into their interpretations of the model runs. As a result they became more supportive of scenario E as a suitable way to manage the system and began to argue for a deferment of the targets by two years combined with increased retention incentives.

This brief list demonstrates the mix of specific business insights and general dynamic insights which was gained. When one notes that this wealth of issues and understanding resulted from work with a model of 28 equations and 5 level variables this becomes all the more striking. The author has observed models which involved hundreds of equations in their pursuit of detail and yet delivered less dynamic illumination than this simple little model. Senge (1990) draws attention to the important distinction between detail complexity and dynamic complexity. The reality is that the richness of insights described here came also from the people who experimented and pondered in the vicinity of the model. The lesson is surely that a model should be used not to store knowledge but to "activate knowledge", in John Morecroft's phrase (1988). The increasing number of cases using system dynamics as a problem structuring framework indicate that it can be a most effective tool for doing just this.

The specific and most important action that was taken as a result of this project should be recorded. Armed with the project account and their improved understanding, the clients approached their colleagues on the computing department's management team. The clients' experience with, and confidence in, the approach, combined with a presentation by two of the author's fellow consultants, resulted in a system dynamics study of recruitment and career progression for the staff across the whole of the computing division in Shell Ruritania. Details of this project may be found in Bryne and Davis (1991).

Establishing the value of this case is important if one is to go on to draw general methodological lessons; evidently understanding how we 'do it' is only of interest if 'doing it' has value. These general observations were of more interest to the consultants and cannot be described here in any length.

Further experience was gained in good computer model building techniques; standards for laying out a model, writing descriptive comments and choosing appropriate variable names. A consequence of this project was a total quality guide, written by the author, describing these good practises.

The department had considerable experience in the creation of system dynamics models but was still working with two different methods of conceptualisation. The recognition of a problem as being susceptible to system dynamics modelling and the elicitation of the reference modes is common to both. The division arises over the use of causal loop diagrams. One method, proposed by Forrester (1968a), is to represent the structure of the system, construct a quantitative model and then interpret its behaviour using causal loop diagrams. Alternatively, one can work with a client on causal loop diagrams to get the main feedback loops in a model which is then constructed quantitively in the next phase. No firm judgement has been reached on which of these methods is the best but the following observations are appropriate. Where a system has many interacting loops it is frequently better to map these out with causal loop diagrams and then try to clarify to some extent via discussion the importance of their effects before beginning to model their make-up in any great detail. In this way it is possible to build a computer model in which the complexity of feedback can be understood by switching on the successive loops and observing the effects as they build up and interact. If a problem has loop complexity which can be allocated into separate sub-systems, then a good approach is to disassemble the model into a number of smaller, isolated ones. These can then be studied carefully until fully understood. After this, the pieces can then be linked together one by one and the changes in response observed (see Forrester (1968b) for an example). In contrast, we would suggest that the use of policy structure diagrams in the case described here worked because, whilst the loops were relatively straightforward and the number of variables was small, the effect of the parameters on the timing of the system's behaviour was unclear.

An important lesson was also gained on means of selling this form of modelling. This project was the first in which a loss leader was deliberately used in order to give a likely client a taste of the project. In this case, 9.5 days of consultant time[3] for three chargeable days paid off because a large project resulted. Success stories, a professional approach and firm promises can only go so far; nothing succeeds like a good reputation, or inviting clients to 'suck it and see'.

[3] Two consultants, so: coloured hats questions (0.5), first meeting (1), main issues board (1), Medler work (1), second meeting (1), model preparation (2), third meeting (1) and project account writing (2). Some time can be written down to training of the junior but there is still a loss.

Of wider interest, the project emphasised the importance of using an intervention technique which limits any biasing in the nature of the issue which is consequently selected for study, a problem commented on and addressed by Rosenhead's book (1989). In this case the clients finally chose a problem which was clearly time evolutionary, in that there was a dynamic hypothesis concerning an evolution to a different state. However, the other two areas of interest on the main issues diagram had much less important time dimensions. For example, with a problem in which choosing between alternatives was the source of difficulty, a decision analysis framework such as that of Phillips (1982) might be more appropriate. Yet a process which quickly asked for curves of variables changing against time, or for feedback loops, could have directed the study into an over-emphasis regarding the time evolutionary characteristic. As the adage goes, "give a child a hammer and it thinks that everything is a nail". There is a crucial requirement to explore general problem structuring approaches. The magnetic hexagon approach used here seems fruitful; further examples are displayed in Eden, Jones & Sims (1983), Checkland (1981) and Rosenhead (1989). For those, like the author, who believe that system dynamics, though a very powerful framework indeed, is not the solution to all problems, this need to be general in first approach must be an important lesson of this study. The work of Richardson et al. (1989) and Vennix et al. (1990) has begun to explore this area. But the question of unbiasing the early stages of an intervention must continue to be high on the research agenda for those of us working in the system dynamics field.

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