Dynamic Resources Management in the Teaching of Project Planning

Craig A Godley

Department of Information Systems, Massey University, New Zealand
E-mail: C.A.Godley@massey.ac.nz;

ABSTRACT: *Project planning is the application of "hard" techniques; and together with a complementary understanding of "soft" factors, the project manager uses both to optimise potential project outcomes. The ability to conduct this balancing act comes from experiences gained in many project situations.*

When learning project management, a student is introduced to "hard" planning techniques, giving rise to a perception that planning may be treated as a "black box" process. Educating a student to understand that this is not the case requires them to experience the consequences of their planning actions.

A simple computer based tool was developed to allow the student to undertake complex planning problems, and from the immediate feedback of outcomes develop their own knowledge and understanding. Concentrating on the resources management aspects of project planning, the software's operations enables the student to see the dynamic nature of resource planning.

Keywords: Project management, Teaching & Learning, Systems dynamics.

INTRODUCTION

There are many examples of projects whose "failures" have resulted from a lack of perception on the part of the project planners to understand the "whole" picture – all of the issues and forces at work within the project context. Those consequences have not only been reflected in financial terms, for example the NZ Police system INCIS, but also in human and social terms. Of all the areas of management where a holistic approach is necessary, project management is the one in which the consequences of getting it wrong are perhaps the most significant.

Studies of the failure to recognise and understand the workings of *all* the elements of a situation have generally focussed on day-to-day management activities. This is well demonstrated in areas such as command and control operations, particularly within the military (Rochlin, 1997). This is rather than considering the consequences of the failure at the planning level.

It is well know that operational systems may be modelled using techniques such as those developed by Forrester in the 1960's and 1970's (Forrester, 1961). His models expounded by "Industrial Dynamics", and the later "Urban Dynamics", took a "hard" systems approach, with little consideration to "soft" factors. Even the seminal work on world modelling by Meadows in the 1970s, recently updated (Meadow et al, 1992), considered a mechanistic approach to the interactions at work in a complex system.

It is through the use of "soft" systems approaches, and the application of conceptual modelling techniques, that human and social factors may be considered. In the context of management, recognition is not enough, and the manager needs to *understand* the processes at work, however ill defined. This is particularly the case when the management activity is that of project management. Here the consequences of the decision-making actions of the project manager will manifest themselves in the future. And, when the future finally arrives, the opportunities to recover from those consequences may be limited, or non-existent.

Formal systems dynamics may well be an approach to use to formulate an understanding of how complex systems work, and from that create more effective levels of management. However, the systems dynamic philosophy can be used to manage the education process so that a student may learn competence prior to entering the work-place. Competency here is not just the ability to apply learned "tools of the trade" in set circumstances, but to recognise the importance of all factors at work in a situation, and from that understand the consequences of their decision-making.

This paper considers the application of a simple computer based tool that allows a student to undertake resource planning in a complex project situation, and gain practical project planning experience.

A SYSTEMS DYNAMIC MODEL OF TEACHING

We need to consider what is being achieved during the learning process, both with formal (structured) education, and experiential learning. Feedback mechanisms are obviously at work, but what is it that those feedback processes are actually doing to the student? Education is the process of changing the student's perception of the world, or at least that part of it that relates to the concepts being learned. The change is that the student has created an internal mental model that forms a foundation to the understanding of the real world. It is that mental model that is brought into play when presented with associated problems. How we can influence and enhance the processes for the creation of an appropriate mental model is at the heart of good education.

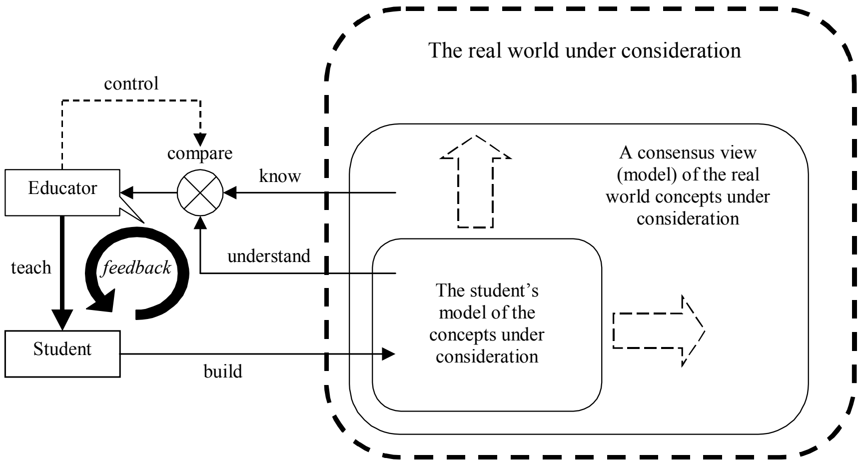


Figure 1: A Teacher Centred Approach to Learning

The "teacher centre" approach is more in line with the traditional and formal systems of education, with the teacher being the main element in the educational feedback loop. In this case the system is educator centred, with the speed, direction and extent of the education (model building) controlled by the teacher.

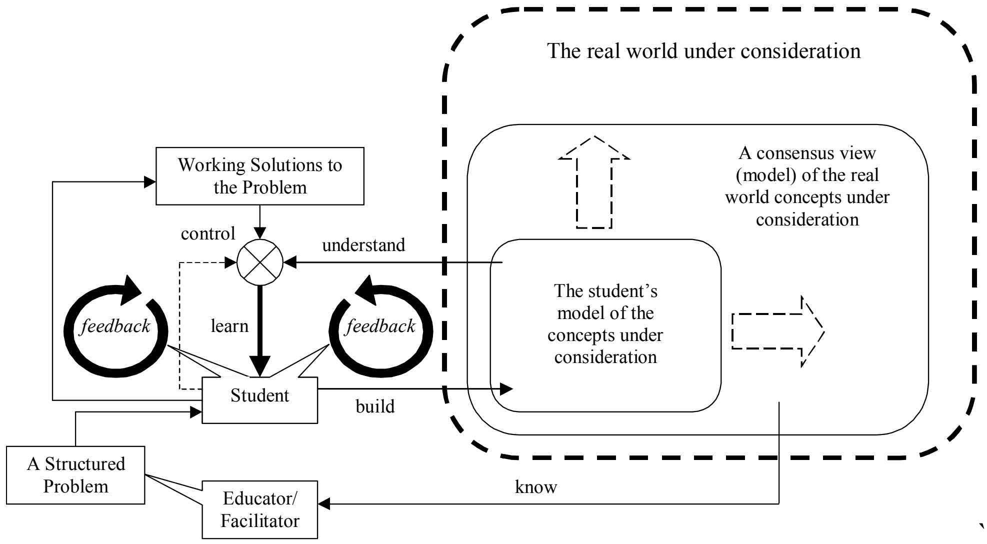


Figure 2: A Student Centred Approach to Learning

However, an alternative to the "teacher centred" approach is present during "student centred" education. For example, learning whilst "on the job". The operation of this system is one in which the student controls the processes that create their mental model, and is more in line with experiential learning. Here the educator is more of a facilitator than a teacher, and where there is a need to control the process, does it through the creation of relevant structured problems.

It is this latter approach that is at the heart of the application of the software tool used in the teaching of resource planning, as discussed further in this paper.

MANAGING THE TEACHING OF PROJECT MANAGEMENT

The use of formal project management techniques, such as GANTT charts and PERT networks, allows complex projects to be planned effectively. However, the project manager has to consider a variety of planning outcomes in order that the defined project objectives may be achieved. Thus, project management requires the application of a wide range of skills, often disparate and in conflict, to problems presented by the project planning process. Good project planning makes use of both formal planning techniques as well as those dealing with understanding the management of people and resources. This is particularly the case when the project manager's comprehension and evaluation of large amounts of information is a necessary part of the decision making process.

Education in project management requires that the whole spectrum of skills be taught. The relationship between the mechanistic processes of formal planning, and the more intangible values associated with people, and resources need to be clearly understood. Being able to convey the need a for a balance between "soft" people-oriented understanding, and "hard" formal planning techniques, is a goal central to the teaching of project management. All factors, not just tangible ones, must come into the equation in order that a good project plan is formulated. Thus, for a student to learn, they need to be placed in situations where they are able to gain experiences of the balancing "hard" and "soft" outcomes, thus putting all the aspects of the project into their true context. Introducing Checkland's CATWOE soft systems approach (Checkland, 1986), or the ICOM conversion process (Maylor, 1996) are useful supports for a student to place the project into its truer context.

Project Planning as a Mechanistic Processes

Techniques such as Critical Path Analysis provide a straightforward way of manipulating project information, and once introduced to them, students tend to like these formal project management techniques. They appear to provide a very straightforward way to tackle a complex problem. Such techniques are purely deterministic in their approach, and a student soon recognises their mechanistic "black box" nature. Provide the technique with tangible numeric information, apply the technique processes, and the solution is forthcoming.

A student quickly recognises this, they feel safe in the knowledge that a "right" answer can be reached, and they tend not to understand that the solution needs to be tempered with a more balanced view that considers other aspects. As the negative consequences of poor project planning may be quite significant, a student must be weaned from this "black box" view of the planning process. A formal teaching approach, see Fig 1, cannot convey the outcomes of this limited view, a student has to experience it for themself, and an approach based upon experiential learning, see Fig 2, is more appropriate.

Integrating all aspects of Resource Planning

Project management concepts, which generally are dealt with singly, need to be brought together, and the student shown how these parts of the planning process have to be considered holistically. Good project planning comes from being able to integrate all aspects of the planning problem. A student not only needs to understand the idea of a critical path, but also need to consider how the "float" or "slack" associated with tasks not on the critical path may be used to optimise planning outcomes. The following concepts have to be accepted and understood, in order that a student may consider project planning in a holistic way:

- There are two type of tasks that make up a project (critical and non-critical), and they have to be considered differently when (resource) planning,
- When resource planning, those allocated to critical tasks are considered first, and to non-critical tasks next,
- The use of float influences how resources may be managed, and the two are closely linked,
- The use of float on one task may influence the behaviour of other tasks dependent on it, and
- The management of one resource may have an adverse affect upon the management of other resources.

It is interesting to note that critical path and float considerations tend to be influenced by the "hard" tangible aspects of the project, whereas resource management tends to be influenced by "soft" intangible aspects.

Only when a student undertakes relatively comprehensive and complex examples can this relationship between the "hard" and "soft" aspects can start to be understood. A difficulty is that calculating the critical path of a project with more than a few tasks and then "smoothing" its resources is time-consuming, so meaningful examples are inappropriate for manual methods.

COMPUTER BASED TOOLS

It is through the use of software packages that educators may present problems of sufficient complexity to overcome the problems of treating the project planning process as a "black-box", and thereby allow integrated learning to take place. With the availability of good graphic based computer software, project planning tools have become much more attractive (seductive!) to use. These could be used, but their capabilities have are far too comprehensive, and the use of fully-featured packages as MSProject needs to be carefully considered. The features that the student needs to support their learning may be buried in the complexity of the package, and the software may offer features that the student is not yet ready for. The danger is that the teaching/learning focus moves towards the package itself, rather than facilitating and integrating the student's learning.

The "Pert" Software

As educators we should not use professional software tools for purposes for which they are not designed and marketed. As the concentration was to be on the problem domain, and not the software being used, specialist software was needed that allowed specific concepts to be targeted. It was in this context that the PERT software was created, with a design focus of:

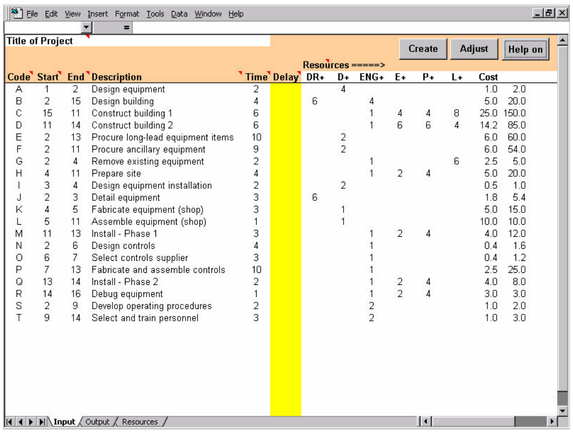
- user interface based on used commonly used software with a short learning curve for effective operation,
- the ease with which complex project information could be stated,
- the graphical presentation of the planning results,
- the speed and ease with which project details could be changed, and
- the speedy feedback of the results of such changes.

Consideration was given to the user interface, and the need for a short learning curve before coming to terms with its operations. Creating specialist software was rejected in favour of a system integrating with Excel - software that a student would be familiar with. An interface based on Excel made for ease of use, and allowing standard "cut and paste" operations enables it to quickly enter project information from other packages.

The result is software that can deal with complex project management situations, and enables the student to concentrate on the interaction of a few manageable parameters. Built-in macros calculate tasks' start and finish times, float, and the critical path.

(a) The Input Interface

The Activity-on-Arrow approach is used, and once the project task has been structured, a minimum of information needs to be entered. Emphasis is on only those items of information - task duration, dependencies, and resources - necessary to specify the project.



Code	Start	End	Description	Time	Delay	DR+	D+	ENG+	E+	P+	L+	Cost	
A	1	2	Design equipment	2			4					1.0	2.0
B	2	15	Design building	4		6		4				5.0	20.0
C	15	11	Construct building 1	6				1	4	4	8	25.0	150.0
D	11	14	Construct building 2	6				1	6	6	4	14.2	85.0
E	2	13	Procure long-lead equipment items	10			2					6.0	60.0
F	2	11	Procure ancillary equipment	9			2					6.0	54.0
G	2	4	Remove existing equipment	2				1			6	2.5	5.0
H	4	11	Prepare site	4				1	2	4		5.0	20.0
I	3	4	Design equipment installation	2			2					0.5	1.0
J	2	3	Detail equipment	3		6						1.8	5.4
K	4	5	Fabricate equipment (shop)	3			1					5.0	15.0
L	5	11	Assemble equipment (shop)	1			1					10.0	10.0
M	11	13	Install - Phase 1	3				1	2	4		4.0	12.0
N	2	6	Design controls	4				1				0.4	1.6
O	6	7	Select controls supplier	3				1				0.4	1.2
P	7	13	Fabricate and assemble controls	10				1				2.5	25.0
Q	13	14	Install - Phase 2	2				1	2	4		4.0	8.0
R	14	16	Debug equipment	1				1	2	4		3.0	3.0
S	2	9	Develop operating procedures	2				2				1.0	2.0
T	9	14	Select and train personnel	3				2				1.0	3.0

Figure 3: Entry screen with sample project data

The student is presented with the choice of only two "Operational" buttons. Used initially once project details have been entered, the [CREATE] button calculates project task and resource details, creating GANTT and resource charts. This button is also used when major changes have been made to the project plan, such as:

- adding or removing tasks, or
- adding or removing resources.

The [UPDATE] button is used to re-calculate project details once relatively minor adjustments are made to the project plan, such as:

- changing tasks parameters, such as task length, resources, etc,
- delaying one or more tasks, thus using float, or
- adjusting the relationship between one task and another by rearranging the nodes that define the relationship between tasks.

The aid the student, a [HELP] button is available which may be used to display simple instructions on how each column is used.

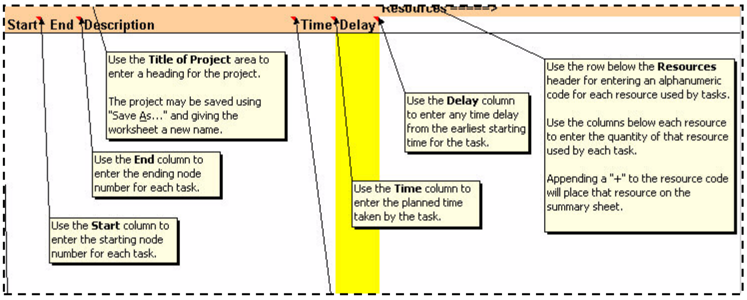
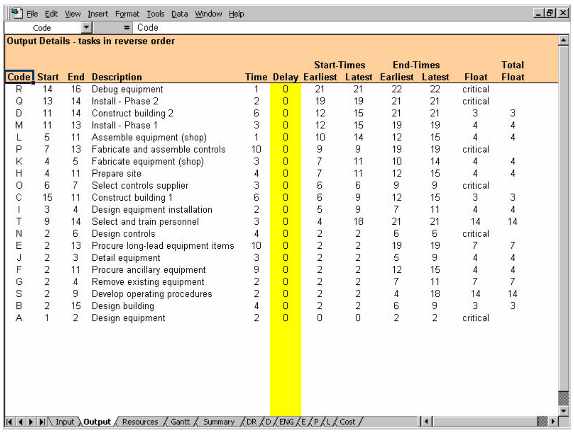


Figure 4: Help screen

(b) The Output Interface

All output screens are self explanatory, with both numeric and graphic forms of output available to the student. The [Output] sheet contains automatically calculated details of the critical tasks and float for non-critical tasks, with the [Resources] sheet containing details of resource allocations over the life of the project.



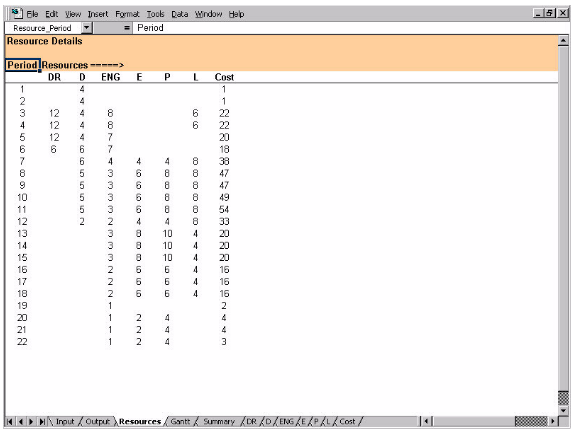


Figure 5: Results of Critical Path calculations

Figure 6: Resource allocations over life of project

From a learning point of view the most important displays are those that show project and resource information graphically. The software automatically creates the GANTT chart, clearly presenting critical tasks, non-critical tasks, and float. Where tasks are delayed float will appear either side of the task bar.

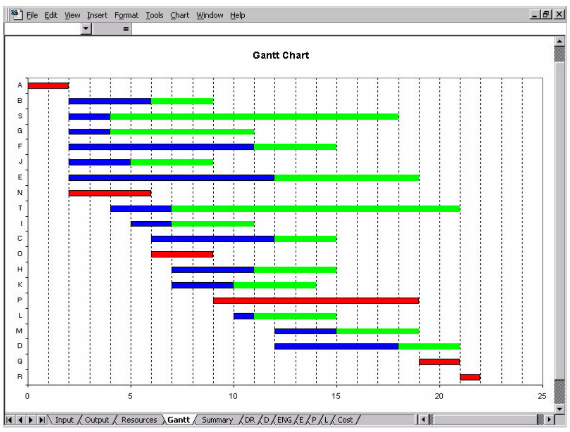


Figure 7: Project GANTT Chart created by the software

The software displays the details of each resource over the life of the project, Fig 8. Also, it is possible to combine the details of selected resources onto one summary screen, Fig 9. From this the student may see the balance between the allocation of one resource with another. Selection of a resource for inclusion on this summary sheet is through appending a "+" onto the resource name on the input sheet.

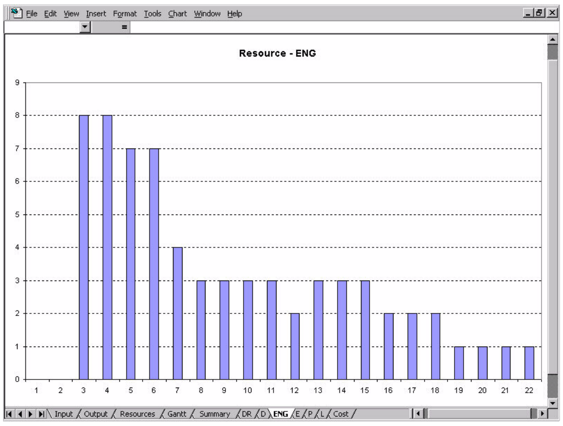


Figure 8: Details of one resource

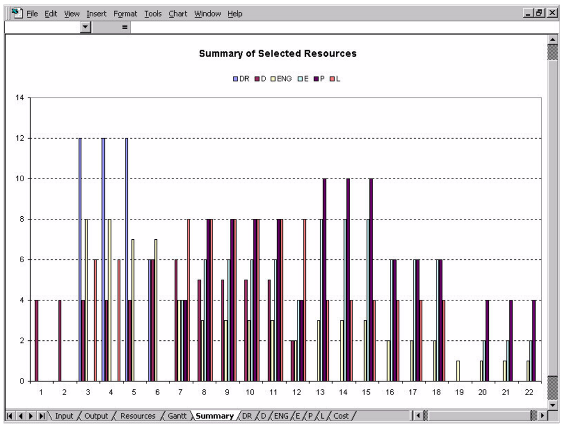


Figure 9: Summary of selected resources

(c) Additional features

Because the software becomes an integral part of Excel, all the features of Excel still are available. Items of input data need not be scalar quantities, but could be calculated from values based in formulae in other cells. For example, unit costs for tasks can be calculated from total task cost and task duration; or task durations may be calculated from optimistic, most likely, and pessimistic times contained in other areas of the spreadsheet.

With problems requiring more complex management decisions, other Excel features may be drawn upon to calculate input data. For example, features such as Solver may be used where the value of task parameters needed to be constrained.

USING THE SOFTWARE

Problems set using this software are ideally suited for use in "formative" exercises, as the student can immediately see the effect of changes to any task and resource parameters, see Fig 2. Not confused with additional, often extraneous features and information, the student's learning is reinforced by the iterative nature of the planning models run with the software.

In a real exercise, the student is presented with a complex planning scenario and specifically asked to set their own planning objectives. Using the software they attempt to meet those objectives by adjusting their project plan and considering the outcomes. Generally the student's pre-specified planning objectives cannot be met, and planning outcomes turning out to be less than expectations. Expectations need to be adjusted – generally down.

Once a final plan has been arrived at, the students is asked to discuss the reasons why some of their original objectives were not achieved. Was it that their objectives were achievable, but the optimal solution has not been reached? Or more likely, it is that their initial expectations are set to high and that a solution could never be achieved. An example of an unrealistic objective may be to set the maximum level for a resource too low a level, and that no manner of manipulation of the project factors would enable this level to be achieved.

To assess the value of exercises such as this, students' reactions to using the software have been collected through the use of qualitative surveys. Initial analysis of the surveys indicates a complete acceptance of the software, and a positive response that individual students have increased their learning. They were willing to spend much more of their own time trying to achieve their objectives, than would have been the case with manual exercises.

CONCLUSIONS

Students benefit in their learning by being placed in an experiential environment. By applying systems concepts to the learning process the operations of experiential learning may be understood.

It is through managed use of this approach that students may come to understand the dynamic nature of complex planning situations. The PERT software tool provides for such an environment, one in which students may build their own knowledge of the dynamics at work. The opportunities to make rapid changes to the project plans, and the immediate feedback through visual presentation of the outcomes of those changes, enables the learning process to be enhanced.

The use of Excel as the basis of the software removes the need for the student to "learn" the software before being able to use it. Results of surveys of students using the software have shown that from their point of view the experiential exercise has been successful, with their concentration being on the problem, the learning experience, and the benefits that accrue from it.

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