An Enterprise Education Module for Engineers and Scientists

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Abstract *— This paper describes the learning objectives, structure and results from a long run ning educational module aimed at introducing career engineers and scientists to the challenges of entrepreneurial management. Entitled 'Applied Industrial Management' (AiM), the learning module has been in continuous development and use since 1969, curren tly utilizing the sixth generation of computer software. AiM has trained six thousand one hundred individuals during one hundred and seventy applications . A self-contained competitive engineering business exercise for between sixteen and sixty - four partic ipants , organised into three to eight working groups , minimum time commitment is twenty hours, with the ability to extend participation time continuously. Groups operate in one of twelve markets with each participant 'role playing' in one of the key areas of marketing, manufacture, finance and executive, this work being set against a demanding timetable. The learning objectives fall into three categories; knowledge development: (on corporate functional roles, outline accountancy and financial analysis meth ods, industrial strategy and structured information analysis) , skill development (group working skills, problem analysis and presentation skills) plus an entrepreneurial attitude towards industrial activity. Operation of the module falls into three distin ct phases; initial briefing, policy selection plus trading and finally debrief. The initial briefing starts with module introduction followed by a period of accountancy skill development in an open learning environment. The final part of the briefing fami liarises individuals on the logistics of markets and company management. Policy plus trading introduces the entrepreneurial and competitive element as syndicates are formed and initially decide the allocation of jobs and company policy. This is rapidly fo llowed by the intensive 'trading' period in which syndicates manage sixteen cycles of defending and building corporate activity. Subject to a strict timetable during each cycle, syndicates are required to implement their selected policies by producing: decisions covering marketing, production and finance against agreed budgets, correct cash flow, trading, profit and loss accounts plus balance sheets, approved annual balance sheets at the end of each financial year for publication and circulation to each syn dicate, estimates of future market and company behaviour using historic information and forecasting. At the same time realistic responses are required to a portfolio of industrial incidents covering new technology innovation, environmental management, div ersification and trading incidents selected to suit the participating individuals and organisations. Debriefing is in two parts; an analysis from the exercise director, using a computer maintained total record of all activity and secondly a 'Directors' le vel presentation by each syndicate of their achievement . The paper will illustrate key events and organization challenges related to the enterprise module and will draw upon the extensive experience of use to identify conclusions on the value of this form of engineering education.*

Index Terms *— Engineering Business Exercise, Enterprise Education, Scientific Industrial Management*

INTRODUCTION

Applied Industrial Management (AiM) is a self-contained competitive engineering business exercise currently for between sixteen and sixty-four participants, organised into three to eight working groups. The largest historic participant group size has exceeded one hundred students and at present the next generation of software is being reviewed from a perspective of up to twenty groups maximum ten students per group or syndicate. Started in 1969 as a paper based exercise, the teaching module has been progressively developed to include computer support, (the sixth generation of software is now in use), topical industrial incidents (a portfolio of eight is currently available) defined role play and group working plus degree level assessment where required.

Five major expansions of the exercise have taken place in a period of thirty-five years continuous use. To date one hundred and seventy presentations of the module have taken place and six thousand one hundred twenty seven participants have taken part [1] [2]. The majority are university students, with twelve universities contributing participants and five universities hosting the module at periods of the lifespan of the module. The module has also been used by public and private corporations as part of recruitment and career directing programmes.

The educational aim of the module is to provide within a challenging competitive environment experience of the scientific stewardship of an industrial company. The specific learning objectives set for participants are grouped into organisational (knowledge and attitudes), procedural (skill development) and managerial as shown in the bullet listings:

Organisational (Knowledge and Attitudes)

- To develop an understanding of the major functional roles within a manufacturing company i.e. Production, Marketing, Finance and Executive.
- To experience the challenge of formulating and implementing company policies as functional managers within a management team.

Procedures (Skill Development)

- Accountancy - To provide self-teaching in accountancy practices including the preparation of cash flow accounts, trading accounts, profit and loss accounts and balance sheets.
- Information Science - To gain an understanding of the potential use of structure information in monitoring and controlling production, marketing, finance and executive activity.
- Forecasting - To develop an appreciation of the role of forecasting in planning the development of company activities.

Managerial

- To introduce, through experience, a basic understanding of the effect of industrial relations, marginal trading and environmental considerations on the effective organisation of companies.

The minimum direct time commitment is twenty hours, divided between briefing (three hours), 'play' (twelve hours) and debrief (three hours). Students support this working time with additional research time and the time for the preparation of three assessments. When student work is complete, there is the software possibility to store a record of all activity and to repeat another twenty hour cycle from the final position, introducing new market and industrial scenario challenges. This effectively gives an unlimited time use of the exercise.

With a variety of technical backgrounds amongst participants, each syndicate works at managing a medium sized manufacturing company. These companies operate in a 'cleaning chemicals' market, where barrels of initially low-technology water and chemical mixes are sold to farming and food-industry buyers as branded products. Role-play exists for each participant, with marketing, production, finance and executive functions being identified. The managerial responsibilities of each of these key roles are explained during briefing and this work being set against a demanding timetable. The ability to be adaptable is brought out and presentation skills are sharpened up as the exercise builds its way through a unique set of 'operational' and 'analytical' activities.

The challenge for the engineers, scientists and new management entrants taking part in AiM is to take their strengths and apply them in the team-oriented, multi-goal environment typical of small to medium sized organisation groups. The outcome is an appreciation of roles within manufacturing business and an understanding of the basic management tools available.

STRUCTURE OF THE MODULE

The three stages of initial briefing, 'play' and debrief commented on in the introduction are illustrated in Figure 1 and Figure 2

The initial briefing, supported by detailed module notes [3], can be organised either as a distance learning exercise or as formal lectures and tutorials, taking approximately three hours. Following the explanation of module structure, learning outcomes and assessment methods an introduction to the size, organisation, managerial decision parameters (e.g. marketing and manufacturing limitations) and corporate objectives of the model companies is given. This is followed by a practical introduction to accounting covering the generation of Trading, Cash Flow and Profit and Loss accounts plus Balance Sheet generation is given. During this introduction the emphasis is on the engineering and managerial meaning of individual accounts. The tutorial on accountancy is followed by a practice session during which participants individually bring up to date the financial records of the model companies. Self tutoring notes on preparing the required accounts are provided for private student practice. Use is made of the completed accounts to describe how to gain useful intelligence in order to evaluate other company's activity and performance.

Analysis of historic model company performance is followed by a review of known market information including sales figures and trends. Company analysis and market reviews are finally expanded into guidelines on the possible stereotype

policies that can be adopted by management teams in this exercise. To complete the briefing participants break up into individual management teams or syndicates to complete group agreed assignments of roles and corporate policy. Adopting their assigned roles as described earlier, the management team then has the responsibility for agreeing a corporate strategy and policies to support this strategy using guidance information provided on Rolls-Royce to Woolworth's stereotypes.

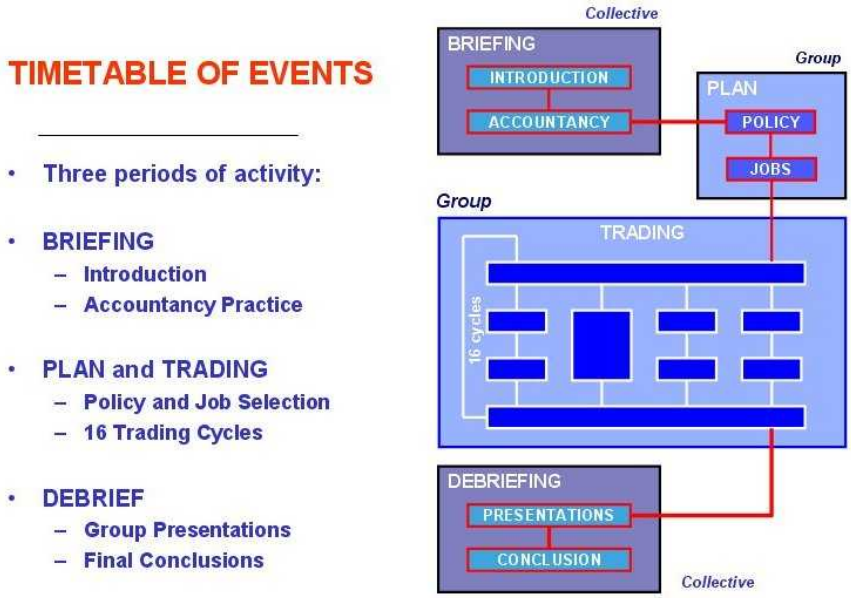

FIGURE 1
Timetable of Events for the Enterprise Module

Trading now commences in working periods of between 45 and 60 minutes, each working period representing one quarter in a sixteen period four year cycle. Syndicates prepare for each quarter by making ten functional decisions (three marketing, five manufacturing, one financial and one executive). In addition time must be taken to read, analyse and react to the many events that are occurring during the exercise. Each quarters trading starts with the submission of all management decisions and ends when the companies are notified of the responses to decisions. The trading clock then effectively stops while companies complete their accounts and prepare for the next quarter. As each quarter effectively starts and ends with the submission and return of decision sheets, all other correspondence and company responses must take place at the same time, i.e. accompany decision sheets. Additional time is given every fourth quarter to prepare an annual balance sheet, which are circulated to each company in order to assess comparative progress.

The trading portion of the exercise is the most intensive activity and is managed by computer software capable of decision checking, allocating resources, managing mail correspondence and organising a selection of 'industrial incidents' covering topics in the areas of wage bargaining, new technology introduction, environmental management, export contracting, joint ventures and management buyouts.

At the end of the four year trading period each company management team is required to account for their performance at an annual general meeting. Time is given to prepare for these presentations, with emphasis on the need to present in a selective corporate style, at which directors of each company are expected to explain:

- the policy of the company and the relative success of this policy, each illustrated by profit, turnover and other related data
- the positive management of any unusual industrial opportunities
- the benefits they have brought to shareholders and the justification for continuing their appointment as directors

The module concludes with an independent review of performance by the exercise umpire, covering market performance, comparative management of challenges, group dynamics and overall learning achievement.

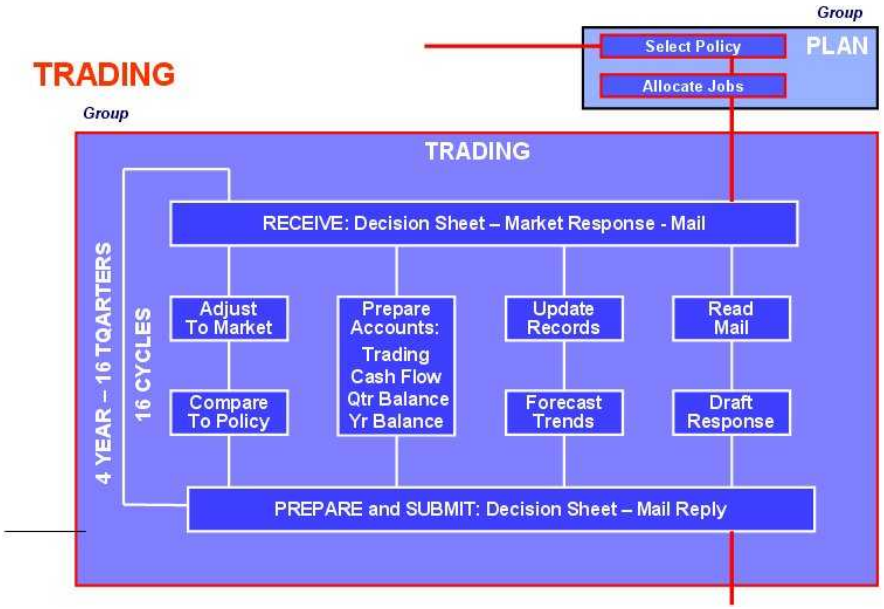

FIGURE 2
Trading Activities during Individual Periods

MODEL INDUSTRIAL SCENARIO

A corporate mission statement for each company provides the starting point, with emphasis on comparative achievement and change:

- The mission of this company is to seek and establish, on behalf of shareholders, a highly profitable and secure market position for both the near and longer term future.
- The positioning of the company as a recognised top performance corporation will be achieved by continual commitment of all internal operations to an ongoing review of efficiency and customer service under the banner of Total Quality Management.

The exercise is set in a specialist sector of the process industries, where each company manufactures drums of cleaning fluid. The drums are a mixture of water and chemicals and each company effectively produces the same product. Companies typically manufacture and sell fifty to ninety thousand barrels a quarter, priced around £12 per drum. The market itself has two characteristics worth noting at this point: the market is seasonal and the market must be satisfied. Seasonal variance occurs in yearly cycles, with a high fourth quarter for the Christmas demand and a low first quarter each year following Christmas. The variance is regularly predictable at 25 percent up in the fourth quarter and 25 percent down in the first quarter on average sales. The total market within the agricultural community has to be satisfied because of the risk of disease. This has a significant effect on companies as each company must deliver the sales made.

In the first instance market sales each quarter will be met out of available company stock and production. Where this fails to satisfy the demand for a company's product the competitors will be asked, in order of cheapest market price first, for their spare stock. This is known as 'label-swapping" or "inter-company trading" and will automatically take place on behalf of each company should they be unable to satisfy market demand. Ultimately, where there is insufficient production and stock available for the whole of the market, then the short-fall will be met on behalf of each company by importing. There will be a premium to be paid above the highest market price for imports and this can be seen therefore to be an expensive activity to become involved in. Figure 3 illustrates one of the twelve available markets, showing the initial five known periods of sales and the computer managed sales profile for the exercise. The use of time-series forecasting is built into the assessment schedule as a means of reinforcing investigation of market behaviour.

There are up to eight potential syndicates or companies within this market at present, each of which starts in exactly the same position, holding equal shares of the market and having equal assets. The aim of each company is to make the maximum total profit in relation to the capital employed. This profit has to be made without prejudicing future operations by failure to retain an adequate market share or a sound financial position. Additionally new directors are reminded that their positions are also dependent on a regular return to shareholders who have invested in the company.

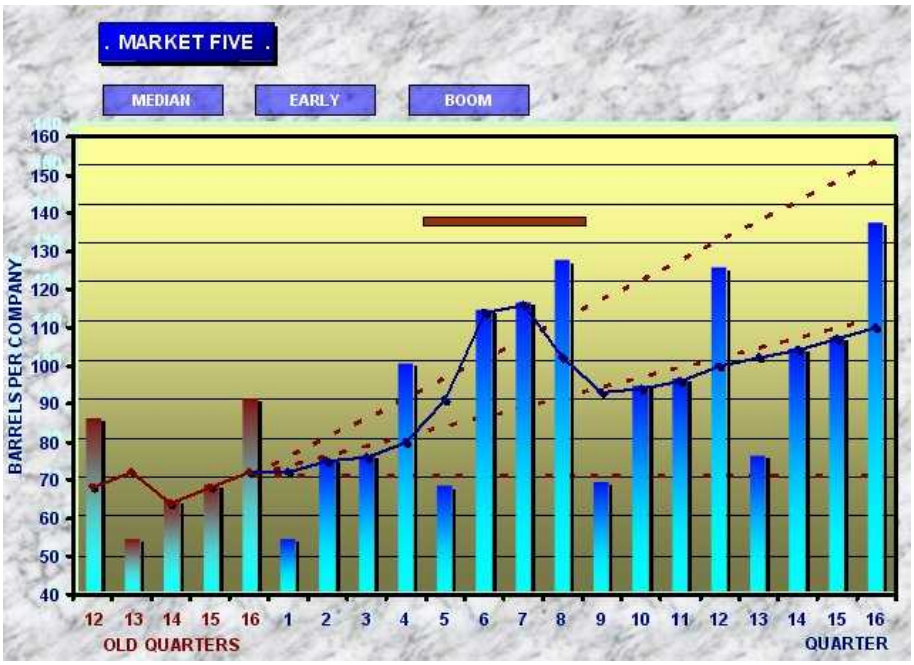

FIGURE 3
A Market Scenario for a Model Exercise

Companies can be considered to be operated by a management team representing four different functions: Marketing, Production, Finance and Executive. How many individuals are placed within each functional group is an internal company decision. The building of a sound management team will dictate however, that roles undertaken will be changed periodically throughout the exercise in order to broaden the experience of participants.

Each company is responsible for marketing their brand of cleaning fluid and for satisfying this generated demand throughout the course of the exercise. The marketing undertaken by each company is represented in the form of a market score. Efforts in the building of a sales force, advertising and price will contribute to each company's market score, which is calculated by the companies themselves as part of the decision sheet submitted each quarter. Companies will receive a share of the total market for a given quarter strictly in proportion to their individual market score divided by the sum of all companies' market scores.

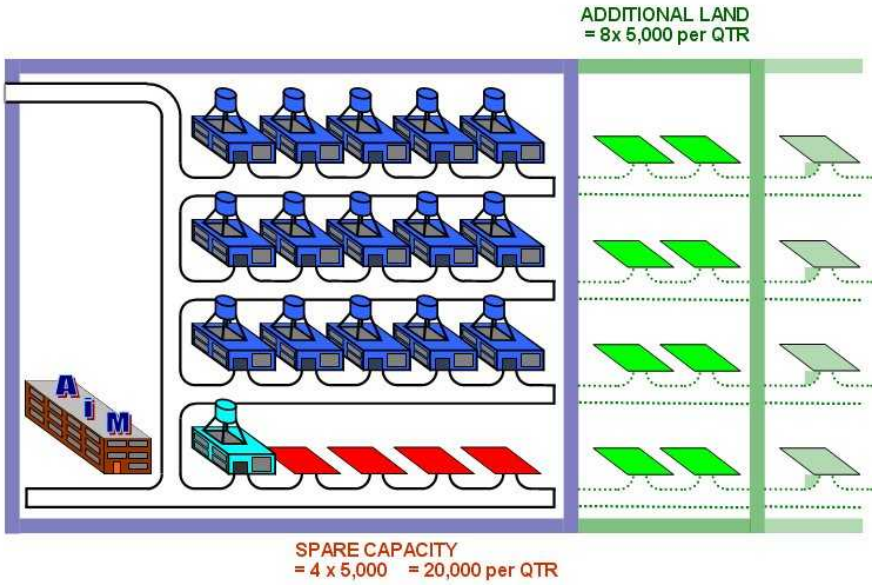

FIGURE 4
Model Company Starting Position

Companies therefore have control over how hard they try to sell their product. The total market quarter by quarter is not known in advance by any of the companies but there will be opportunities to forecast the market as the exercise progresses and management information accumulates.

In order to be able to respond to the market, companies are not fixed in size and there is ample opportunity to both expand and to achieve higher productivity. The actual change in the profile of companies will be dictated by the company's own chosen policies and by the nature of the management team's performance in the market place. Production therefore has two sets of tasks; firstly they must balance the quarter by quarter production requirements and secondly they must build up the long-term profile of the company as set out in the company policy. The initial physical model of companies is shown in Figure 4. At the start of the exercise there are fifteen existing and one new building capable of producing five thousand barrels each with space remaining for four additional buildings. Further expansion requires both land and buildings. The combination of efficiency and size investment creates a challenging changing scenario.

The true role of finance has two components; the calculation and reporting of financial progress, a passive role related to accountancy requirements and the timely provision of financial resources, an active role. The monitoring task involves the preparation of cash flow, trading, profit and loss and balance sheet accounts each quarter. The timely provision of financial resources will involve the raising and repayment of loan capital throughout the exercise. Errors in timing will lead to the requirement to discount future income at comparatively high rates. A frequent mistake made by engineers and scientists is to underestimate and misunderstand the role of finance within companies. The overall company policy will give direction to the activity of executives and budgets provide the authority to expend resources. Finance is responsible for providing the resources and does not have the task of limiting the activity of other executives. The challenge is to maintain timely and accurate financial information using all computing resources in order to avoid financial difficulties.

In addition to the functional roles of Marketing, Production and Finance, a co-ordinating function is included. Referred to as the Executive role, the main tasks involved here are the co-ordination of decisions in the form of a decision sheet each quarter, the review and evaluation of correspondence on behalf of the company and the general monitoring of progress in implementing the selected company's policy. The previous company' performance, organised under the four functions just described, has just completed a four year cycle which produced, it is believed, relatively unsatisfactory results. The new syndicates take over from this relatively unsatisfactory position and manage a fresh four year plan of events.

MODULE EXPERIENCES

Participants in the module can be categorised into two types; formally assessed and experience gaining (the equivalent of auditing). The majority of participants are involved in assessment as part of their undergraduate or graduate degree studies. The highly interactive nature of the modules limits the amount of pre-study before contact. As a result the initial period of briefing involves a steep learning curve. The first noted observations is the immediate use of free time by students to catch-up and complete the accountancy training. For the majority of numerate scientists and engineers taking part this presents an opportunity to use their basic strengths and many make immediate use of computing resources to support their work. The commitment of auditing students is weaker and often computer printout support is needed.

Allocation of roles is generally tentative, with more technical students selecting the accounting role and frequent discussion on the exact tasks associated with the executive role. Group size is observed to clearly affect individual performance. With small group sizes (four per syndicate), students settle to role play quickly and maintain their roles. With large group sizes (six to eight), a committee approach develops with consensus decision making. This is actively discouraged and particularly at the point of role change. The largest group size is not commonly used, the preference being for more syndicates, as the peer review process and student observation has shown a higher incidence of weaker students 'coasting' through their allocated tasks.

At least one role change is enforced, usually at a time of high exercise activity. This reminds students industrial careers involve job change and modern management requires breadth of experience. Notable reactions include attempts to remain in a previous post, particularly the numerate accountancy role and the emergence of a 'teaching role' across job functions.

For assessed students there are currently three assignments and a peer review. The first assignment, in the area of time-series analysis, provides an opportunity to apply numerate skills whilst strengthening their range of analysis tools within each company role. The final two assessments, a group presentation and shareholders report are designed to take students away from analytical thinking. The requirement to be selective in information presentation, to place as high an emphasis on style

as content in order to deal with focused objectives related to securing shareholders support proves challenging to students. Student responses to these assignments divide between excellent shareholder style reports and uninspiring technical analysis.

Post module auditing, part of university quality management, shows a high student acceptance rating, with assessment levels repeatedly in the top percentile, indicative of the participative exercise and the progressive learning experience.

COMPUTER SUPPORT

Applied Industrial Management is supported by a bespoke data file and software package. In all, the sixth generation of software has fifty-three data files, forty compiled integrated programs and ninety-one standard memos and documents, used to create and manage each exercise run. AIM6.1 software, the present generation, is capable of:

- Creating and initialising data file structures
- Module preparation including parameter setting, incident selection, market selection and initial printouts
- Simulation of each time period including file preparation, data entry and validation, decision making, incident control, printing and post-processing data file updating
- Module management data output
- On screen information access

The software is designed to allow the re-running of any individual period and a total record of all decisions is maintained allowing post exercise analysis. The next generation software, based on Visual Basic, is currently under development with the objective of allowing larger target groups and internet access. Selections of software screen shots are given in Figure 5 through Figure 8.

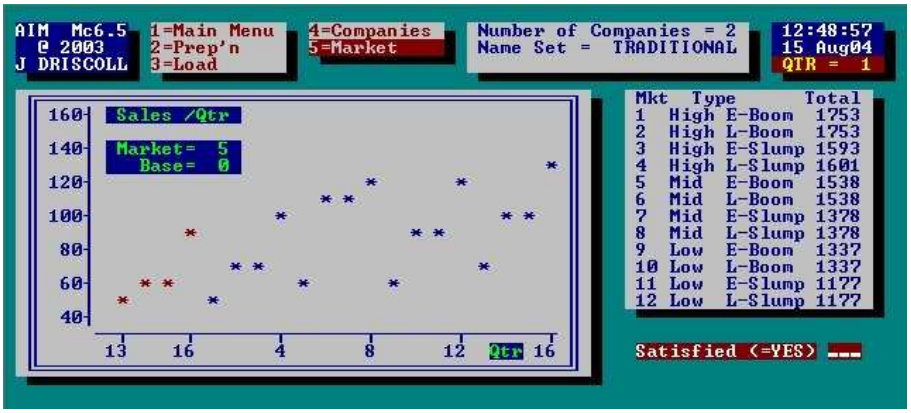

FIGURE 5
Software Market Selection

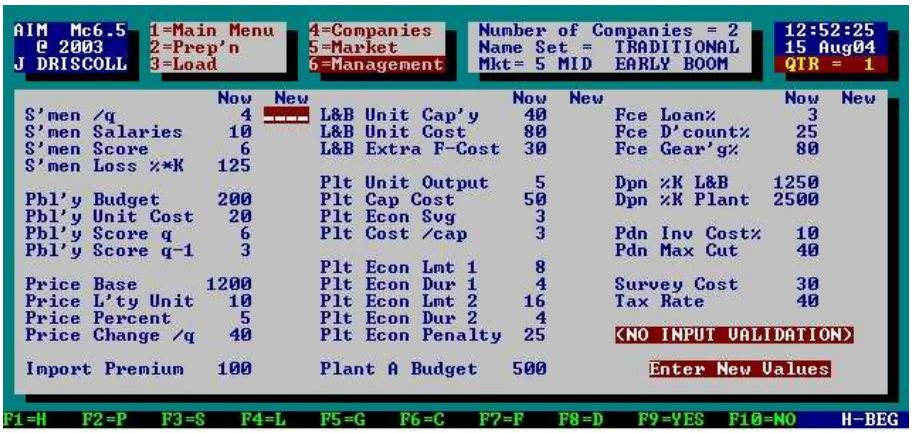

FIGURE 6
Software Parameter setting

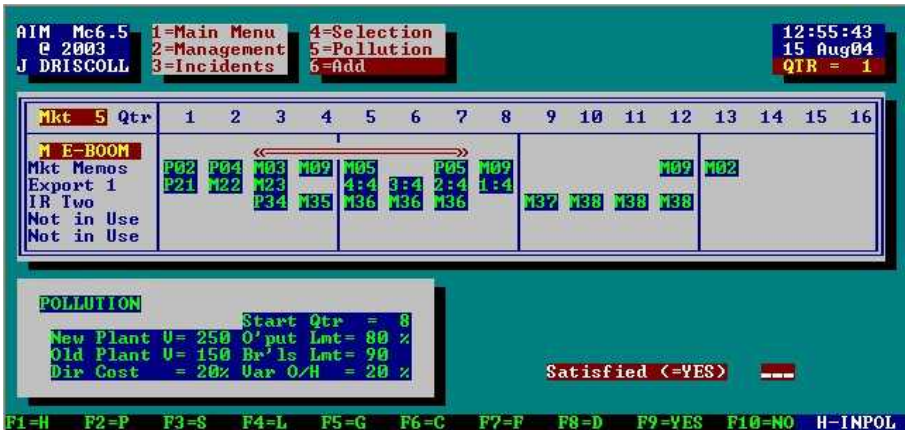

FIGURE 7
Software Incident Management

FIGURE 8
Software Simulation of Market Response

CONCLUSIONS

Within this paper the outline structure of a computer supported 'enterprise' education module has been described and the areas of computer support and module experience commented upon. The following general conclusions are drawn from the topic of the paper:

- Student centred learning based on competitive achievement goals provides a stimulating learning environment generating student commitment.
- Movement away from traditional analytical teaching and assessment can provide reinforcing experience of early career industrial work practices.
- Tailored assessment related to variable student learning experience is possible and provides a counter to increasing group submissions.

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