Validation of a simulation of information systems development project management.

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Information Systems Project Manager is a new computer based simulation/game representing an information systems development project. It aims to complement traditional teaching methods by letting students 'manage' a simulated information systems development project. This paper reports on a study into the validation of this simulation using participants from different backgrounds, considering criteria of psychological reality, structural validity, process validity and predictive validity. It evaluates the simulation in terms of its contribution to the participants' understanding of Information Systems project management, and their feedback about the simulation. The paper reports on the first stage of this work, that is, with student participants. The conference presentation will also present a complementary viewpoint from experienced practitioners.

Introduction

Simulations and games are now widely accepted as a powerful mode of teaching and learning in social science, complementing more traditional teaching methods by encouraging learning by doing, by generating motivation and enjoyment, and by engaging the student in a simulated experience of the 'real world'. Yet despite an apparent resurgence and proliferation of games for general business and marketing (Lane, 1995), the literature gives few examples of simulation/games supporting information systems courses, especially those with a management flavour. Information Systems Project Manager (ISPM) is a new computer based simulation/game representing an information systems development project. Martin et al (1999) describes the motivation and design of the simulation/game, whilst this paper focuses on the issue of its validation.

It is recognised that there are many difficulties with evaluation of simulations (Megarry, 1987). First, the objectives of the simulation include a significant experiential element, the communication of a feel for the practical issues in IS project management. It is likely that benefits from this experience will be felt beyond the academic course and cannot be measured by traditional techniques. Second, it is impossible to hold constant all the variables except the experience of the simulation, and separate its contribution to an holistic understanding of the topic from the wealth of other experiences of the individual. Third, evaluation sometimes reduces to the question of whether the simulation/game is more effective at, say, communicating concepts of IS project management, than traditional lectures or case studies. Megarry sees this as unnecessary, partly because the onus could equally be reversed (can traditional methods be proven to be more effective than simulations?). More importantly, as here, often the author has no wish to claim that the simulation/game is more effective than other teaching methods, simply that it is an effective complementary technique.

In theory, research could be designed to counter these problems. In this instance however the greater need is felt to be simply to examine whether the simulation does indeed generate a valid, meaningful experience to support the teaching objectives. A dual approach is taken whereby not just students but also experienced practitioners are consulted about the learning experience.

The paper first introduces the simulation, describing its main features. It discusses a theory of validation that informed the design and gives a framework for evaluation. The results of participant surveys are analysed, and lead to a discussion of the insights gained into the role of the simulation as well as its limitations.

Information Systems Project Manager

The learning objectives of the simulation/game are:

1. to stimulate awareness and understanding of some of the concepts, language and issues of information systems development.
2. to provide an integrative view of some of the tasks and practical dynamics of information systems development project management.
3. to present some of the differences between diverse approaches to information systems development.
4. to communicate some of the 'softer' elements of IS project management such as staff morale and user buy-in
5. to generate a sense of experience of managing trade-offs made between conflicting tasks, dealing with unplanned eventualities in project management, and living with the consequences of such decisions.

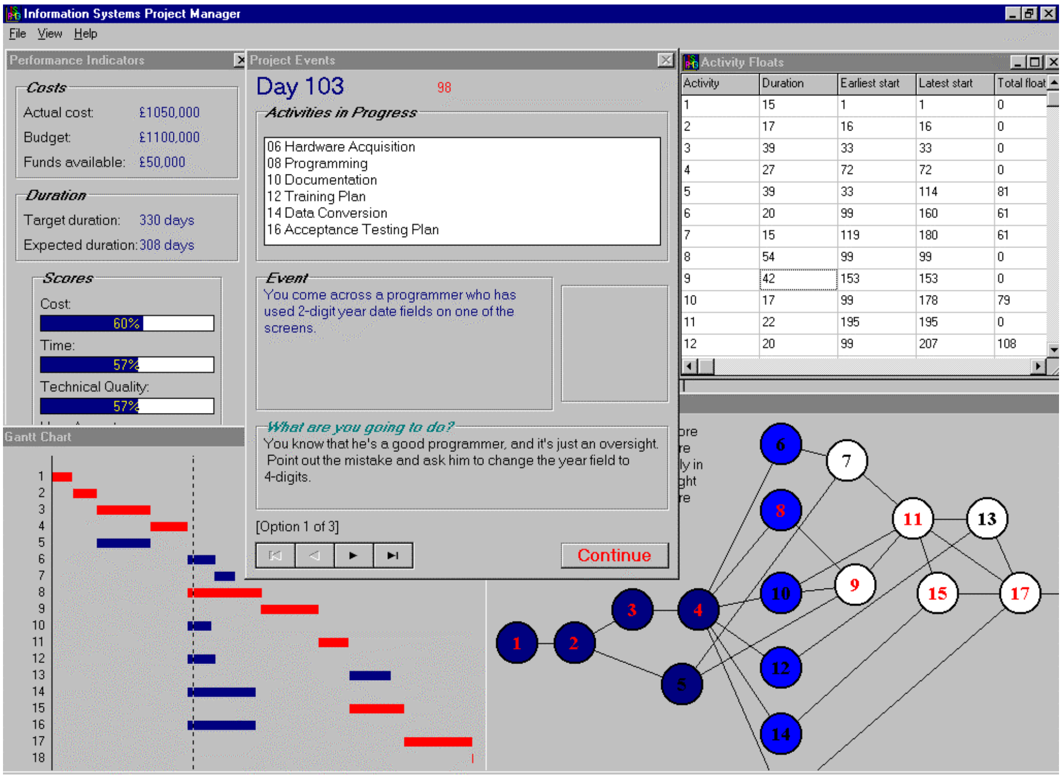
The operational objective for each participant is to manage the development of an information system; the individual (or group) takes the functional role of Information Systems management in an organisation. The participant must address specific management decisions involving trade-offs between alternative courses of action, some at the tactical/operational level, some at a more strategic level.

The content of ISPM is structured around the project management and traditional information systems development life-cycle concepts (Alter, 1999). The project model is a natural one for information systems developments, since they are typically formulated as one-off initiatives with inter-dependent activities, a methodology, resources such as a budget and staff, and with the traditional project performance indicators of cost, time and quality.

Players see the following 'forms' on the screen (figure 1):

- event occurrences, described further below
- key performance indicators as gauges, which include cost, time, technical quality and security as well as softer ratings such as user acceptability of the system being developed and staff morale. These gauges are updated automatically in response to events and actions .
- project network
- Gantt chart showing progress to date
- project activity floats

Figure 1: Typical screen layout for Information Systems Project Manager



Information Systems Project Manager presents an interactive unfolding of the project as a series of events through time. The main type of event presents a wide range of planned or unplanned technical and management eventualities related to information systems development. Events include staffing problems, changes to the requirements, technical and operational problems and opportunities such as fires, viruses, delays and security issues. Events may or may not occur depending on, for instance, the time, the quality of the current activity, the current level of morale, the player's response to previous events, or ad hoc initiatives taken by the player. Player decisions must be made in response to each event by selecting from a number of options, each of which has different consequences. The response affects the cost, time, technical quality, user acceptability, morale or security 'state' of the project, and, importantly, may also schedule other events.

In addition to dealing reactively with computer-generated events such as those described, the players are also able to make proactive interventions. They may, for example, acquire capital resources such as system development tools, check project progress, keep in touch with staff and users ('management walkabout'), or initiate ad-hoc quality and security checks. Further, the manager can bargain with staff using overtime payments to secure additional resources to save time. Dealing with these eventualities forms the central part of the simulation and forces participants to relate theory to practice. 'Soft', less tangible issues are included, such as relationships amongst the management team and with end users. In this way the game's perspective differs from a purely technical software engineering viewpoint.

The simulation has been used to support an undergraduate module named 'Information Systems' at Warwick Business School. This module addresses management issues associated with the broad process of information systems development. The simulation will also be shown to representatives of experienced system developers from a major UK airways company and a major UK bank. The validation of the simulation is based on these subjects' views, and was carried out in the first half of 1999.

Validation theory

Raser (1969) proposed strict simulation validation criteria of psychological reality, structural validity, process validity and predictive validity. Peters et al (1998) interpret these criteria for teaching simulations, relaxing the Raser's criteria in the following ways. They question whether, if validity is the degree of correspondence between the reference systems and the simulated model, that correspondence has to be one to one. Instead, Peters et al argue that the correspondence has to be 'sufficient for the purposes of the simulation/game'. In terms of outcomes, Raser suggested that 'a model can be said to be valid to the extent that investigation of the model provides the same outcomes as would investigation in the reference system'. Peters et al suggest that although this might be suitable for physical models or for research into the phenomena themselves, it is less suitable for management or teaching simulations. In terms of the four criteria:

- **Psychological validity**: Peters et al propose that 'A game is valid to the degree that it provides an environment that seems realistic to the players. If they fail to see the game as realistic, they possibly tend to show different behaviour than they would in real-life situations or they tend to take more risks'.
- **Structural validity**: Peters et al suggest that 'the elements in the reference system and the relations between them … should be reflected in the game model'. 'Because modelling means that we try to build a simplified model of the reference systems, it is not necessary that all elements and relations be represented in the game model'. It is sufficient for the most important features to be included in the game model.
- **Process validity**: In a similar way to structural validity, processes such as the flows of information or resources, and interactions or negotiations between actors, should be reflected in the game model.
- **Predictive validity**: Raser considers that 'a game is valid to the degree that it can reproduce historical outcomes or predict the future'. Peters et al accept that the results of the game can be compared with the result in reality, in order to generate confidence in the simulation's predictions about future situations. However they argue that predictive validity is not necessary for teaching simulation/games, where the aim is to teach people about the reference system or how to act in a new situation, rather than to directly emulate the reference system. They conclude that there is more latitude for game design, and that the game is valid to the degree that the learning objectives are achieved by the participants.

Peters et al's interpretation and application of Raser's criteria for validity present a realistic yet challenging framework for assessing the contribution of a simulation/game. In summary, the simulation must be perceived to reflect the most important aspects of the situation it purports to model, particularly structure and process, and must support its learning objectives. Their main suggestion for increasing confidence in validity is to review the simulation with peers and experts. In this work the experienced practitioners are the primary judge of structural and process validity, and the student participants are consulted to establish what they have learned and their perception of the simulation's validity. The practitioners can also judge whether this perceived learning is valid. Predictive validity is not claimed since the objectives relate primarily towards teaching. Peters et al discuss ‘threats of validity’, which help to frame questions concerning structural and process validity:

- Reduction: have we left anything out, or included peripheral elements; are the wrong concepts emphasised?
- Abstraction: have we over-simplified for the purpose intended. Is it too vague or two detailed?
- Symbolisation: is the translation appropriate or has something been lost? Would participants see the link with the reference system?

Such weaknesses might occur from either inadequate account of the objectives of the game, inadequate knowledge of the reference system or by the designer being too strongly focused on the model.

Research Methodology

All students on the author’s Information Systems module at Warwick Business School 1998-9 were required to participate in the simulation. They were invited to join in the research elements voluntarily. It was made clear that test results were not to be used towards the assessment, although modest prizes were offered for the most useful feedback as well as for the best scores in the simulation. Anonymous student ID numbers were used to identify the answers at all times. All volunteers were given a ‘pre-test’ before participating in the simulation. This consisted of 8 main questions concerned with different aspects of IS project management broadly covered by the simulation. This test took place in classroom conditions and took about half an hour. Following the simulation students were given the same questions in a ‘post-test’, without reference to their previous answers. They were given supplementary questions to allow direct expression of their learning from the simulation. 28 usable responses are analysed below. A copy of the instrument may be obtained on request from the author. There was no control group, which would have been ethically unfair in a live course situation. The main focus is therefore on the changes in response, which is assumed to be attributable to the effect of the simulation. It is recognised that this is not the most robust research structure, but was the most realistic option.

Analysis

The analysis of the results is presented by question, showing the ranked order of response by the students both before and after the simulation. Significant changes are discussed. A change was considered significant by a large change in rank order or, more systematically, by a statistical test. In general the mean response went up ($p<.025$, questions 1-6, $p<.07$, question 7, not significant question 8), possibly indicating an increased awareness of the importance of most of these variables, but arguably reflecting an arbitrary shift in relative response. In order to offset this general shift, and to identify the main learning points, the post-test results were normalised to the same mean as the pre-test results, question by question and student by student. Differences in mean response across students were then tested for significance between student-pairs of corresponding results. Effectively the statistical test is for a significant shift in deviation from the mean response within each question. The detailed analysis shows which particular variables were perceived by the students to be of increased importance, and therefore emphasised by the simulation.

1. Key elements contributing to a successful IS development project.

Before

1	Clear specification / objectives
1	Involvement of the users / clients

After

1	Competent Project Manager
2	Adequate resources (including time)

3	Good communications		3	Clear specification / objectives
4	Competent project team		4	Competent project team
5	Responsiveness to clients		5	Good communications
6	Adequate resources (including time)		6	Responsiveness to clients
7	Appropriate overall approach / methodology		7	Involvement of the users / clients
8	Competent Project Manager		8	Adequate planning, estimating, scheduling
9	Adequate planning, estimating, scheduling		9	Appropriate overall approach / methodology
10	Senior management support		10	Adequate management control mechanisms
11	Adequate management control mechanisms		11	Senior management support
12	Experienced team		12	Explicit risk management
13	Explicit risk management		13	Experienced team

Competent Project Manager rose significantly (p=.017) and Adequate Resources rose (not significantly). This is consistent with the overall essence of ISPM, which was about the successful management of scarce resources. *Involvement of the Users / Clients* dropped significantly (p=.013). This is something of a surprise and is not consistent with student's other statements.

2 Key difficulties encountered in information systems development projects.

Before			After	
1	Changes to requirements		1	Changes to requirements
2	Conflicting viewpoints concerning the objectives		2	Lack of resources
3	Lack of resources		3	Conflicting viewpoints concerning the objectives
4	Conflict within the project team		4	Technical problems (hardware or software)
5	Instability of the project team		5	Conflict within the project team
6	Intangible product		6	Size of the project
7	Size of the project		7	Instability of the project team
8	Newness of the project		8	Intangible product
9	Technical problems (hardware or software)		9	Newness of the project

Technical Problems is increased in perceived importance (p=.006); several of the events in the simulation do report technical problems. The difficulties from the *Intangible Product* nature of the information system has decreased in perceived importance (p=.001). Perhaps the simulation represented the project so clearly that the intrinsic intangibility of these key performance measures was not perceived. Further, ISPM does not stress the conceptual design of the information system, so the intangibility of IS design is not communicated.

3. Broad contributions that the project manager can make to ensure the success of an information systems development project.

Before			After	
1	Communicate with the project client		1	Balance the conflicting objectives of the project to a satisfactory outcome
2	Balance the conflicting objectives of the project to a satisfactory outcome		2	Address unexpected difficulties as and when they arise
3	Maintain the quality of the project		3	Maintain project team morale

3	Maintain user / client commitment to the project		4	Maintain user / client commitment to the project
3	Address unexpected difficulties as and when they arise		5	Communicate with the project client
6	Allow for contingencies		6	Maintain the quality of the project
7	Maintain project team morale		7	Allow for contingencies
7	Plan the project thoroughly		8	Maintain system security
9	Manage the project through to completion on time		9	Manage the project through to completion within budget
9	Maintain senior management commitment to the project		10	Securing adequate resources are available for the project
11	Securing adequate resources are available for the project		11	Manage the project through to completion on time
12	Manage the project through to completion within budget		12	Maintain senior management commitment to the project
13	Maintain system security		12	Plan the project thoroughly
14	Contribute 'hands-on' when required		14	Contribute 'hands-on' when required

The need to *Maintain System Security* increased in perceived importance (p=.0003). This was one of the key performance indicators highlighted by ISPM. So was Maintain Project Team Morale, whose importance rose, but not significantly. Although not significantly changed, it makes a great deal of sense that Balancing the Conflicting Objectives and Addressing Unexpected Difficulties were perceived as most important, since they were core to the nature of the simulation, as described earlier. These points were also reported by students amongst their major learning points. Similarly, Manage the Project through to Completion within Budget rose in importance, though not significantly. The importance of Communicating with the Project Client dropped in rank although not significantly. This again is a surprise, although it is noted that maintaining client commitment is still perceived as important.

4. The contribution of specific resources to successful information systems development.

Before			After	
1	Appropriate methodology		1	Staff training courses
2	Staff training courses		2	Appropriate methodology
3	Backup and disaster recovery plan		3	Backup and disaster recovery plan
4	Computer Assisted Software Engineering tool		4	Virus protection software
5	End-User development resources		5	End-User development resources
6	Application packages		6	Computer Assisted Software Engineering tool
7	Fourth Generation Language		7	Fourth Generation Language
8	Virus protection software		7	Application packages

This issue was not central to the simulation and was not answered systematically by many students. The main change in perception was the importance of *Virus Protection Software* (p=.0002); this was undoubtedly due to the event by which any participant who failed to acquire virus protection software was duly presented with a virus problem!

5. The importance of specific uses of the IS Project Manager's time.

Before			After	
1	Consultation with users		1	Consultation with users
2	Communication with senior		2	Project progress and performance

	management			monitoring
3	Project progress and performance monitoring		3	Communication with senior management
4	Quality testing		4	Management walkabouts
5	Management walkabouts		5	Quality testing
6	Security audits		6	Security audits
7	Hands-on design / development support		7	Hands-on design / development support

From inspection of the table, there is little major change in ranks. However the increased scores for *Management Walkabouts* (p=.01) and decreased score for *Consultation with Users* (p=.044) and *Communication with Senior Management* (p=.01) are significant. 'Management Walkabouts' was a feature of the simulation, and students reported using this feature extensively. Communication with Senior Management received a relatively low profile in the simulation, with only one relevant event. Hands on support ranked lowly & less important after the simulation; the simulation definitely presents a hands-off view. Consultation with users remains important in contrast to the reservations from question 1.

6. The proportion of time the typical project manager actually spends doing specific activities

Before			After	
1	Dealing with day-to-day difficulties		1	Dealing with day-to-day difficulties
2	Monitoring progress and performance		2	Acquiring and deploying resources
3	Acquiring and deploying resources		3	Monitoring progress and performance
4	Securing senior management support		4	Maintaining client / user support
5	Planning ahead / re-planning		5	Planning ahead / re-planning
6	Maintaining client / user support		6	Securing senior management support
7	Hands-on design and construction		7	Hands-on design and construction

Maintaining Client / User Support rose in importance (p=.032). Securing Senior Management Support dropped in rank but did not significantly change its score.

7. Evaluate the effectiveness of each of the following tactics or principles for dealing with day-to-day eventualities and difficulties?

Before			After	
1	Maintain project team morale		1	Deal with possible problems at the earliest sign
2	Deal with possible problems at the earliest sign		2	Maintain client / user support
3	Maintain client / user support		3	Deal with each situation on its merits
4	Maintain organisational support for the project		3	Maintain project team morale
5	Maintain the project strategy but adapt the plan		5	Maintain organisational support for the project
6	Deal with each situation on its merits		6	Maintain the project strategy but adapt the plan
7	Minimise disruption to the plan		7	Minimise disruption to the plan
7	Adapt the strategy according to project pressures		8	Adapt the strategy according to project pressures
9	Deal with problems when they impact on performance		9	Deal with problems when they impact on performance

Maintain Project Team Morale dropped in rank and significantly in mean score (p=.04). *Maintain Organisational Support for the Project* dropped (p=.032). Deal with Possible Problems at the Earliest Sign rose marginally significantly (p=.065) to become the most important factor. This tactic is close to the heart of the simulation in practice; 'a stitch in time saves nine'. Students confirmed this as an explicit learning point. Maintain Client/User Support remains a highly ranked tactic.

8 Evaluate the effectiveness of the following management styles for successful information systems development projects?

Before			After	
1	Consultative		1	Consultative
2	Considerate / diplomatic		2	Considerate / diplomatic
3	Pragmatic		3	Play safe
4	Take risks		4	Pragmatic
5	Play safe		5	Take risks
6	Tough		6	Tough
7	Dictatorial		7	Dictatorial

The approach of *Play Safe* increased in importance (p=.006). Clearly, students were influenced by the sustained stream of problems that occurred in the simulation. Students in similar simulations have observed that it did not pay them to take risks, and this appears to be a learning point; whether it is a valid learning point is debatable. Students also observed that 'being cautious costs money', since playing safe trades off money (or time, quality or morale) against the risk of an adverse eventuality later.

ISPM Learning and feedback

The second part of the participant feedback elicited learning points and reflections on the game using Likert scale ranking and open ended questions. The most frequently cited learning points are:

- the need to trade off between the different performance measurements
- the importance of softer, people factors e.g. morale
- that early investment in resources pays off later
- the need to address problems at their earliest signs
- that there are many unexpected difficulties which the Project Manager is expected to deal with
- the need to think ahead and 'anticipate the unexpected'
- the importance of user involvement

Most of these points were categorised by the undergraduate students as 'reinforcement' rather than new or deeper understanding, confirming the role of the simulation as supporting other teaching. Students reported that most of the learning was gained during the simulation itself, rather than during formal or informal reflection or debriefing. They felt that they had learned equally as much about project management in general and about information systems projects in particular.

Psychological, structural and process validity

Students were asked how close to real life they thought the simulation was in terms of the structural and process attributes listed below. Their mean response was on the 'realistic' side of average in all cases except the information available and the options available. The students found the project and people issues most realistic (>3.5), which meets one of the aims of the simulation, to include the softer aspects of management. This is consistent with their reported learning. 'Options available' refers to the strongest current criticism, that the options are unrealistic or insufficient.

Lack of 'Information available' probably refers to specific information about the size, nature of the project, the individuals involved and some details of the events encountered – such that in particular it was not always easy to respond to an event.

	Mean score (1=Unrealistic,5=Realistic)
The nature and duration of the pre-set structural activities of the project e.g. design, programming	3.3
The structure /inter-relationships of the project activities	3.6
The representation of people involved in the project	3.7
The activities and role of the project manager	3.8
The opportunities for proactive initiatives:	
Management walkabouts	3.1
Quality reviews	3.1
Security Audits	3.1
User Group Meetings	3.6
Buy Resources	3.3
Overtime function	3.0
Staff training	3.6
The information available	2.9
The management controls available	3.1
The options available in response to events	2.9
The nature of interaction with events?	3.4

Evaluation of the simulation

Students were asked to state what they most liked the most common positive points were:

- ISPM presents a view of real life systems development. This was the most frequently cited positive point, with 9 of the 28 mentioning it explicitly without prompting in learning points.
- ISPM was a fun, interesting learning experience
- ISPM gave instant feedback, both from the performance indicators and the post-project review
- ISPM was easy to use (1.9, .85 on a 5-point scale from very easy to very difficult)

The most pertinent criticisms are that:

- the options and supporting information are constrained and consequently sometimes lose realism
- some of the decisions were difficult to address due to the generic nature of the project, for example with respect to the size and nature of the project team. This was felt to be in some senses a very mature criticism; in other ways perhaps students fail to see the general principles in operation.
- 'It depends' – several students stated that their response in real life would be contingent on the project, size, team, stage etc.

The students were also asked to compare their learning experience through the simulation with that from other simulations, lectures and case studies, in an attempt to partially address the issue about comparative effectiveness of teaching methods. Analysis of the responses shows that in terms of the amount of learning, ISPM ranks with lectures as the highest; in terms of the depth of learning, ISPM ranks highest, followed by lectures and case studies; in terms of enjoyment, ISPM ranks highest followed by the other simulations. This indicates a very favourable reaction to this particular simulation. In line with the reservations at the start of the paper, such responses should be interpreted in the context of their course and should not be taken to indicate that lectures should be displaced by simulations.

Discussion

The evaluation shows that although there is room for further realism in some events and options, the simulation scores well in terms of psychological validity. Its practical realism, ease of use and interactive nature are its main attraction to students, particularly in contrast to the more theoretical lectures. Structural and Process validity will be further judged by the practitioners in due course. The final and acid test is whether the learning objectives are realised. Referring to the learning points given earlier:

1. Understanding of the concepts, language and issues is not tested explicitly, but by expressing their own learning points, students have shown that they have begun to use the language in a sensible way.
2. The integrative nature appears to be appreciated by the stated learning points above, particularly the appreciation of the relationship between events, decisions and their consequences in terms of trade-offs and problems either solved or caused. Answers to question 3 indicated that an holistic view was being developed.
3. Given the sketchy answers to question 4, it is considered that the simulation currently fails to give adequate appreciation of the different approaches to information systems development. This was not noted as a learning point.
4. Students seemed already receptive to softer ideas, but these were maintained and reinforced by the simulation, particularly by the explicit morale performance factor. Softer 'people' factors rank highly in most questions and the learning points.
5. The sense of experience and trade-offs dealing with and living with decisions was at the heart of the simulation its learning was well supported by questions 3,7 and the learning points.

Many of the learning points principally involve practical management issues and address practical problems. The simulation therefore meets its broader objective of complementing traditional teaching by confronting students with the practical application of the principles. Students felt strongly that the simulation was giving them a realistic view of practical project management. ISPM presents a perspective from which the students feel able to learn and apply theory in a meaningful way.

Some apparent contradictions in learning with respect attitudes to users were reported above. It may be that some students felt that user involvement was important enough to state it as a learning point, however on average it was not seen as the most important criterion for success. In contrast, the need to maintain client support was consistently rated highly, and consultation with users was considered an important use of the Project Manager's time. Perhaps participants were able to separate the two, considering that support need not come from direct involvement.

The strong learning points about investing money and addressing problems early were not explicit teaching objectives. They may reflect on the author's outlook and experience, or arise out of the possibilities enabled by the game structure and the felt need to teach students lessons!

I have noticed differences of opinion amongst students about the value of hands-on support, reflecting a genuine difference in attitude or approach to project management. This was observed not in this simulation but in more practical simulations used in the same module. Questions 3M, 5G and 6C all referred to the degree of hands-on involvement by the project manager. In ISPM all three questions show the students as retaining a low opinion of the need for hands on support. However one student commented that the degree of hands on management depends on the size of the project, which in this simulation was unknown.

Conclusions

This paper has used a theoretical framework to validate the Information Systems Project Manager simulation. The framework emphasises structure, process, psychological validity for the participants and achievement of its teaching objectives.

It is clear that the simulation has been influential in shaping the students' understanding of IS project management. The simulation presents a strong framework for appreciating the management process of developing information systems, though in general terms only. It encourages students to put Information Systems and Project Management theory together and apply them to very practical scenarios. Whilst students have some reservations, it is clear that they considered overall that they had a meaningful and valid experience that was valued highly alongside lectures and case studies. The simulation emphasises practical, operational and tactical issues more than general, strategic issues. Students' understanding is influenced by the performance measurement as well as by the event content.

The simulation is psychologically valid and, since the learning objectives have broadly been met, subject to views from practitioner experts, the simulation can be said to be valid. Further input from practitioners will be reported live at the conference and can be communicated to enquirers from the address given.

The simulation can be further developed, fine tuning the events to ensure appropriate learning, in particular developing the events and options to increase their realism and hence psychological validity. It should address or review its objective of teaching different methodological approaches. Some thought could be given to whether a more specific project should be represented, for example a large e-commerce development.

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