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Use of "Flight Simulator" for Training IT Managers in Investment Decision Making

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In this paper it has been suggested that the findings of research on managerial decision-making may be relevant in IT, but that research needs to be carried out on the factors that influence the decisions of IT managers in order to develop an effective "flight Simulator". While this is useful as a first step, the paper argues that a systems thinking/ systems dynamics approach is necessary for developing flight simulators as learning environments for managers. The advantage of SD is not merely that it captures the complexity of decision-making processes; it also offers a way of exploring the impact of change on decision-making over time. The paper describes the model, identifies a number of propositions that can be derived from it and suggests how these may be tested empirically through a flight simulator.

1. Introduction

Improving the information Technology (IT) investment evaluation process has become an important area of research and professional practice [Young 2002; Cohen et al. 2000]. Investment evaluation is a complex and dynamic decision making process as there are many interacting factors that impact on the choices made by the decision maker. There is some evidence to suggest that the introduction of system dynamics-based flight simulator as learning environment can be effectively used to promote understanding and improve learning of complex application domains in which management decision making take place. Improving managerial learning process effectiveness is arguably one of the most important aspects of research and development in education [Scriven 1960; Erwin 1991; Levin 2000; Jin 2002]. Despite technological benefits of the emerging tools to facilitate and leverage a broad range of cognitive learning processes [Pfahl et al. 2001], and the significant progress made in educational research [Levin 2000], seldom has flight simulators been used as a form of computer based instruction [Spector et al. 1998] which is claimed to foster effective learning, and enhanced problem-solving to managers [Young 2002].

In research and development education, Brown [1992] further extended in Levin [2000] calls for contemporary educational intervention that synthesises discourse of design experiments and other classroom-based studies. Levin [2000] further argues "*demonstrations studies and design experiments have their place in the developmental stages of educational intervention research*" [pp 201]. The advances

in instructional technologies and explosion of simulation tools are changing how managers work and make decisions on the day-to-day basis. Current improvements in the world economy, both industry and business are searching ways to improve their competitiveness, hence the need for experienced and well-trained decision support analysts. Various researchers have claimed that advanced technologies, like system dynamics simulation tools [Forrester 1961; Fisher and Zahara 1997; Sterman 2000; Spector et al. 2001] might fundamentally change how the learning process occurs [Draper and Swanson 1990; Isaac and Senge 1992].

In the paper a systems thinking/systems dynamics-based flight simulator approach is used to model the impact of change on IT decision-making. The paper further examines how this flight simulator could be used to improve decision-making and proposes a programme of future research.

1.1. Research Issues

Business and industry environments in which managers make decision are constantly changing, there by increasing demand for technology to increase productivity to support effective and timely decisions. This has led to developing decision support systems one of the most difficult and challenging tasks in many organizations. Higher education is not immune to these developments. In response to the demand for decision support analysts, higher education have designed curriculum for learning and teaching decision sciences [Williams 2002]. System dynamics-based flight simulators can be viewed as opportunities for postgraduate decision support education to leverage learning effectiveness [Dunlap and Gabringer 1996]. The focus of classroom experiments is the simulation of a specific decision making process and to learn from it.

The use of simulation methods in classroom settings is growing, however, Cohen et al. [2000] emphasise that "there is an increasing need to evaluate claims concerning the advantages and effectiveness of these newer approaches against more traditional methods" [pg 79]. The advantage of the use of a flight simulator in decision support systems is that the subject's humanity is left intact in that students are given a realistic situation in which to act in whatever way they think appropriate. Another advantage of the simulation approach, is the inclusion of time dimension in flight simulators that allow the students to take an active role in interacting with the learning environment and the experimenter the opportunity of observing a social process in action with its feedback loops, multidimensional causal connections that may help in improving our understanding of the effectiveness of flight simulator learning environment [Palys 1978]. Feedback from "flight simulators" can stimulate changes in the students' mental models about managerial decision support. Such learning involves new understanding, reframing of a decision situation and leads to new goals and new decision rules, not just new decisions.

These issues raise the following research questions (RQ) that will be investigated:

RQ1: How sensitive to the characteristics of the learning environment are decision rules that managers use?

RQ2: How can these flight simulator-learning processes be captured in models?

RQ3: What types of feedback experiences and training might mitigate learning environment and develop our systems thinking capabilities in decision making context?

RQ4: How can IT Managers improve their decision making process?

2.   Related Literature

Flight Simulator

In investment evaluation, design experiments have been used [Levin 2000; Brown 1992] as experimental research strategy in classroom intervention [Cohen et al. 2000], however system dynamics based flight simulator as learning environment have not been used before. Sterman [2000] calls for the creation of managerial practice fields "flight simulator". The underlying concept of rehearsals and practices can be central to successful team performance in training of aircraft pilots. Although flight simulator environments have focused on military aspects of planning and training, however they have not been used in higher education setting to teach and training managers learning decision support systems [Cohen et al. 2000]. In the System Dynamics (SD) literature, researchers have proposed the use of either case study or purely problem simulation. Researchers have not stated the advantages of combining the two research methods neither have the relative merits of quantitative (simulation modelling and qualitative (case study) been examined and debated [Williams 2000].

IT Managers

The term 'IT Manager' is used throughout the paper to describe an occupational group whose members 'plan and oversee multiple projects and project managers and work with CIO's and senior managers to determine systems development strategy and standards' [Juliussen and Juliussen 1996]. The term 'IS manager' is sometimes used instead of, or in addition to, IT manager in the IT/management literature. The difference is one of emphasis. IS managers are more concerned with the management of information; IT managers with the management of the technical resources used to gather, process and disseminate information to different levels of the organisation [Ward et al. 1990]. This is justified on grounds that knowledge of the technical aspects of systems management is vital if organisations are to keep pace with the rapid rate of technological change and make sound decisions about IT investments.

Why are IT Managers Different?

i.   The rapid pace of technological change and the demands imposed on IT managers make the decision-making environment more fraught and complex than for many managers. The high turnover rates at the senior levels of the IT organization and the widespread criticism of IT managers' ability to handle management and business issues with which they have been confronted suggests that organizational change may place enormous strain on decision-making competence [Flynn and Williams 2000]

ii. Psychological factors that cause managers to convince themselves that things do not look so bad and that continuation will eventually lead to success [Brockner 1992]. These factors include the manager's previous experience with similar projects, the degree to which the manager feels personally responsible for the outcome of the project, as well as psychological and cognitive biases that can affect the way in which information concerning the project is perceived or proposed [Keil 1995 Pg: 423].

iii. Another type of bias can lead to "throwing good money after bad" in an effort to turn around a failing project (Garland 1990)

Investment Decision Making

The decisions that managers make regarding IS investment most times impact on the cost and eventual success of the IS systems that are put in place. In addition to this, the eventual cost of the IS investment may also depend on the decisions that these managers make. When making these decisions, it is important for them to be well informed with quality information, so as to come out with informed decisions. Accampo [1989]as quoted by Murphy and Simon [2002] states that "quantitative techniques can be hard to apply to ,activities in which information is the key commodity". Murphy and Simon [2002] contend that "many of the measures found in the IS literature that are used to evaluate system success are intangible" and that "traditional methods of project evaluation fall short if these measures cannot be quantified in monetary terms". In their work on system success, Delone and McLean [1992] have observed that System quality and information quality are related to sytem development; and system use and user satisfaction are relevant to implementation. In this study, system use and user/customer satisfaction reflect expectations of the customer. Delone and McLean [2002] state that information quality and system quality, are the most important quality components to measure the success of an IS in an organisation. On the other hand, Reicks [200]) states that "most people want access to the right information, as they recognize that sharing the right information with the right people at the right time, can empower these individuals". This helps them make the right decisions. Khalifa and Liu [2004] conclude that perceived benefits (IS success) are measured by expectations, ease of use and perceived usefulness.

Several authors have highlighted problems associated with IS investment which makes it unique. Some of these are:

Complexity of IS projects- It has been found that Information systems themselves are complex social objects inseperable from the organisational context within which they are situated and the infrastructure supporting them, and are products of history and human agency [Symons 1994]. This means that they affect the people who use them and are in addition affected by these very people. Many IS projects are designed to improve the operation of business activities that are dynamic, complex, non-linear systems which cannot be readily understood by using static modelling approaches. The dynamic systems are characterised by interactions of closed chains (or feedback loops) that, when combined, define the structure of the system and hence how it behaves over time [Kennedy 2001].

This affects correctness of output and makes it difficult to estimate the exact expenditures and therefore benefits [Marquez and Blanchar 2004].

IS investments are dominated by multiple view points which are not captured using current evaluation methods [Marquez and Blanchar 2004].

The role of soft factors such as motivation and perceptions has also not been appreciated in IS investment literature [Caulfield and Maj 2002]. If you omit soft variables you run the risk of failing to capture something essential to driving human affair

Poor information quality impairs decision making and promotes inefficiency. One reason for this is that managers depend on this data to order for equipment, select suppliers and contractors.

3. Factors Affecting It Managers Decision Making

The existing body of literature identifies factors that affect IT managers' decision making. Also the literature point to the significant differences the way managers make decisions. It is now possible to turn to the factors identified in the management literature as important in decision-making and consider how these may influence IT managers.

Organisational factors are likely to have a significant influence on the decision-making behaviour of IT managers. It could be argued that IT managers employed in organisations that depend on IT are likely to take decisions about IT that differ in nature and complexity to those of managers working in organisations that are less IT intensive or have a culture that is not supportive of IT or technical innovation. IT managers in organisations that are dependent on IT may play a more significant role in strategic decision-making and enjoy more influence in the decision-making process at all levels than IT managers in organisations that regard IT as a backroom activity. Although this may suggest that IT managers are in an ascendant position, the trend towards devolving responsibility for IT to the business areas and increasing user responsibility for IT and control over the IT process may undermine this trend. Whatever the precise status of IT managers, the greater involvement of users and increasingly complex IT structures

in organisations have almost certainly increased the complexity of the decision-making process. The ability of the organisation to learn and to ensure that learning is passed to organisational members may be another organisational factor that influences the decision-making behaviour of IT managers. Clearly, if the organisation has created mechanisms that distil learning from past events, the IT manager will be able to utilise this in the decision-making process.

Another key factor that influences decision-making is change in the external environment [Cooke and Slack 1984]. In recent years, major changes in the economic and political environment in which firms operate, the introduction of new "enabling" technologies, changes in social attitudes and demographic patterns combined with the general growth of competitiveness have resulted in dramatic changes in the strategic direction of many organizations [Doherty and Nyham 1996]. It could be argued of course, that the factors that influence IT managers are the same as those that influence other managers. There is some evidence to show that this is not the case. Studies of personality differences between IT professionals and general managers, for example, suggest that they are more intuitive and analytical and are less influenced by emotion than general managers [Lyons 1985]. This may mean that they are less swayed by sentiment or practical considerations when making decisions. An understanding of these differences is clearly important if decision-making in IT is to be improved, particularly since IT professionals are under increasing pressure to "hybridise" and become knowledgeable about the business [Earl 1989; British computer Society 1990; Earl and Skyme 1990; Jones 1993; Flynn and Williams 2000].

The types of decisions taken by managers obviously reflect the nature and purposes of the business [Cooke and Slack, 1984]. The structure of an organization may influence both the ease and effectiveness of decision making.

Decisions regarding the strategic direction of the organization influence the business rules that guide decision-making at lower levels of the organization. Thus if senior managers change strategic direction, decision-making at every level of the organization will be affected [Flynn and Williams 2000]. The speed with which change in strategy can be implemented is dependent on management information about change and the availability of systems to disseminate that information. It seems reasonable to assume that managers who have access to high quality information and IT used to support decision-making are likely to make more competent decisions than those who do not have such facilities [Flynn and Williams 2000].

One of the ways in which organisations can store and distil learning about important events is through the use of IS/IT. A factor that may have a very important bearing on the decisions IT managers make may therefore be access to information and IT support. IT managers who lack access to information are likely to make ill-informed and poor decisions. The fact that IT managers are frequently involved in the design, development and implementation of Management Information Systems (MIS) and Decision Support Systems (DSS) presumably

means that they require an understanding of the decision-making process and the factors that affect decision-making. It is ironic that so little is known about the decision-making behaviour of the managers responsible for delivering the systems that help other managers make decisions on which the survival and well being of the organisation may rest.
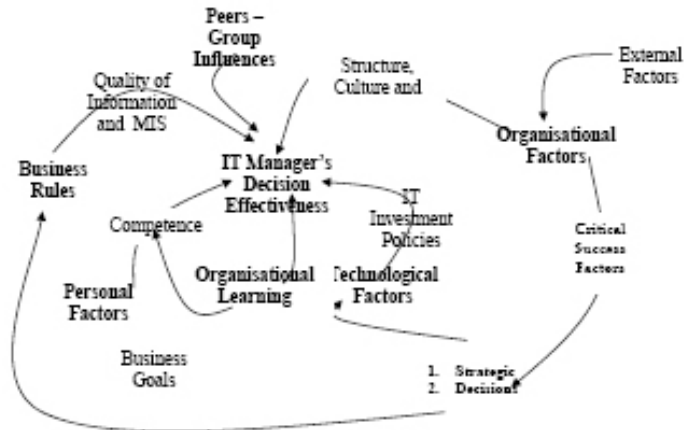
The idea that the IT department should be a centre of innovation suggests that IT managers are at the centre of change processes in organisations. Indeed they are frequently referred to in the literature as 'agents' or managers' of change.[Earl and Skyrme 1990; BCS 1990]. The question of how change may affect IT managers and how it might influence decision-making, however, has not been the subject of detailed investigation. Is there any reason to suppose that they behave differently from other managers? It could be argued that IT managers are more accustomed to dealing with change and are therefore more likely to deal with it effectively. This may be true of very experienced managers and managers in organisations that have been established long enough to have accumulated experience in dealing with change. However, the rapid pace of technological change and the demands imposed on IT managers make the decision-making environment more fraught and complex than for many other managers. The high turnover rates at the senior levels of the IT organisation and the widespread criticism of IT manager's ability to handle the management and business issues with which they have recently been confronted suggests that organisational change may place enormous strains on decision-making competence.

4. Model of the Factors that Influence Decision-making

The model over page (see Figure 1) provides a starting point for understanding the range of factors that influence decision-making in IT. At the centre of the model is the IT manager. The decisions he/she makes is depicted as being influenced by the factors described in the previous section. Personal factors are shown to be important as are the influence of peers and the groups to which the manager belongs. Personal and peer/group factors are subject to the influence of organisational factors - the structure, culture and political ethos of the organisation, its goals, quality of information available, etc. "Business rules" are shaped by the organisational context and strategic objectives, while investment policies are influenced by technological factors and are also shown to have an impact on the IT decision-maker.

The model also suggests that organisational learning may have a direct impact on the individual IT manager's ability to learn and to make effective decisions.

Fig. 1: Factors that Influence Decision-Making of IT Managers (based on Williams & Flynn, 2000)

Peers – Group Influences

Quality of Information and MIS

Structure, Culture and

External Factors

Organisational Factors

Business Rules

IT Manager's Decision Effectiveness

IT Investment Policies

Competence

Critical Success Factors

Personal Factors

Organisational Learning

Technological Factors

Business Goals

1. Strategic
2. Decision

The Model is useful insofar as it depicts the main factors that influence the decision-making of IT managers and indicates some of the possible interrelationships between them. However, it does not depict the process, delays, complexity or dynamic nature of decision-making in IT. If decision-making competence is to be improved, it is necessary to go beyond merely listing factors that influence decision-making and consider the dynamic nature of the decision-making process. Pidd [1996] contends that if organisations are to deal with the complexity of systems and decision-making within systems, there is a need for a new way of thinking about decision-making. Systems thinking/systems dynamics offers a vehicle for conceptualising the dynamics of the decision-making process [Morecroft and Senge 1990; Sterman 1994]. The next section explains the nature of the systems thinking/systems dynamics approach and highlights its potential in understanding the decision-making behaviour of IT managers.

i) It has been shown that IS managers frequently lack a full understanding of their organizations business and are often not involved in the senior management decision-making of the company [Andresen 2000]. Senior management who do understand the business and have to make the decisions are usually not comfortable with the emerging information technologies. [Andresen 2000].

ii) When considering new IS investments, senior management seldom have feedback from previous investments to provide comfort for their earlier decisions. [Ballantine and Stray 1998].

iii) Complexity. Although significant numbers of IS projects are routinely completed successfully,a recent study on the state of IS in the UK carried out by Oxford University and Computer weekly reported that a mere 16 % of IS projects were considered successful [Sauer and Cuthbertson 2003].

iv)   Visualisation. IS project outcomes are effectively invisible. This visualisation problem is a source of many IS project failures.

v)   Traditional analysis focuses on the separation of individual pieces of what is being studied. Systems thinking, in contrast, focuses on how the thing being studied interacts with the other constituents of the system-a set of elements that interact to produce behavior of which it is a part. This results in sometimes strikingly different conclusions than those generated by traditional forms of analysis, especially when what is being studied is dynamically complex or has a great deal of feedback; like IS investment projects have.

vi)   *Management Support*- Top Management support refers to the senior executives favorable attitude toward and explicit support for the IS [Doll and Torkzadeh 1991]. When top management is highly supportive of IS, greater resources are likely to be allocated to develop and support information systems [Sabherwal et al. 2006]. This improves the decision making capabilities of IT managers.

From the diagram, by enabling the visualization of the factors at play in the investment process, complexity is reduced. In case complexity is increased, understanding would be impaired, but if reduced, understanding would be enhanced. With increased understanding, there is increased management support which leads effective management decision making. This now calls for newer approaches in Investment decision making.

Integrating emerging technologies to design flight simulator-like learning experiences is of high pedagogical value and andrological. The technological and pedagogical implications of designing such state-of-the-art learning environment can extend the pedagogical objectives to include concepts and dimensions that are usually difficult to communicate [Pfahl et al. 2000; Wang and Newlin 2002; Jin 2002], if not impossible for a manager that has not had an exposure of mathematics or computing, to reach through traditional educational methods. The flight simulators developed should not be viewed as an answer to the problems, but rather as a vehicle for exploring many of the problems reported in the literature [Levin 2000]. Several tentative propositions can now be drawn from the literature and suggests how they may be tested.

P1: There is a time lag between the a IT manager gaining understanding of the decision environment technical potential and the manager's understanding of their own information requirements and choices at the time of decision making process.

The flight simulators will make a useful starting point for developing a theory of the manager's learning decision making process and managerial decision support training.

P2: The quality and availability of information has a major impact on the IT Manager's capacity to respond to choices and satisfaction with the decision-making process.

P3: IT Managers, who have access to high quality information, and use flight simulators to support decision-making, are likely to make more effective management decisions than those who do not have flight simulators at the time of decision making process.

Managers in Information Systems are faced with increasingly dynamic, complex, and uncertain environment in which to make decisions. Modern Science does not reflect on all reality, but only on that part that is ordered, isolatable, predictable and controllable [Heylingen 1997; Cilliers 2005; Gershenson and Heylingen 2005]. A different set of tools is required to navigate this increasingly complex environment [Gershenson, 2007]. Rapid technological advances, information explosion, and the widening gap between the developed and underdeveloped countries of the world all contribute to today's complex environment [Daellenbach 1994].

Fundamentally, a system is complex when we cannot understand it through simple cause-and –effect relationships or other standard methods of analysis. Every year there are more people, more computers, more devices, more cars, more medicines, more regulations, more problems [Gershenson and Heylingen 200]). This results into more complex information systems.

A distinguished researcher in role-playing, gaming and computer simulation, van Ments [1978], proposed a design process for using students and suggests that, in educational setting, one may use simulation as situation from which others may learn. The underlying system dynamics model's most distinctive feature is that it can deal with mathematical concepts and user-friendly technology that support decision making process. As suggested previously, the inadequacies of current decision support models make it difficult to capture the complex relationships and feedback loops that characterise the decision-making processes. This "fly by wire" concept of the learning process has been used in organisations to facilitate learning [Senge 1994] but it has not been used as a basis for developing manager' decision-making effectiveness. The research will apply Dynamic Synthesis Methodology, grounded on well-tested and developed theoretical anchors and builds on an existing epistemological of science in the acquisition of knowledge (Williams 2001), as a basis for theory building and extension in the areas of problem-solving field.

5. Flight Simulator for Investment: A Case Study

The use of dynamic synthesis methodology to develop a "decision explorer" as flight simulator learning environment will make significant contributions to the literature and to knowledge as to how managers learning difficult concepts like those common in investment evaluation process. The concept of decision explorer has not been explored in the literature nor has it been applied in educational or training context. The results of such a study have also significant implication for student life long learning process [Yin, 2002] and manager who may wish to learn or train using the decision explorer.

One advantage of using system dynamics models over more traditional models is the inclusion of feedback effects. This makes the model's output more realistic

and exposes complexity that may be hidden in other modeling techniques. Thus, decision makers can more easily identify the interrelationships in the environment of the model. Feedback occurs in another level as well. As managers practice with the simulation, their understanding of the environment changes. They learn from the feedback the model gives them.

Sterman emphasizes thus "Learning is a feedback process. We make decisions that alter the real world; we receive information feedback about the real world and using the new information, we revise our understanding of the world and the decisions we make to bring the state of the system closer to our goals" [Sterman, 1994 Pg 291].

Building a Flight Simulator

Building a flight simulator is accomplished in four steps, that is; charting the trends or patterns of behavior; finding the variables; using system thinking tools to build causal loop diagrams and finally using stock and flow diagrams to build a dynamic model. Simulations are run on the model to test policies and decision rules. When the results are satisfactory, an interface is added to allow non-technical users interaction with the flight simulator. By doing this we are empowering the managers and promoting team learning.

Reference Modes

In System Dynamics research, reference modes constitute perceived qualitative mental models about key variables that are problematic and central to investigation. They would essentially constitute what the manager perceives as the behavior of the phenomenon over time. These are plotted and we then move on to the next stage of identifying the key variables.

Identifying Key Variables

In identifying the key variables, we are trying to establish the system's dynamics. This reveals the factors that make it change over time. When managers are exposed to this kind of reasoning through participation, they soon learn to identify the most important issues instead of moving around in circles.

Building a Causal Loop Diagram

According to Maani and Cavana [2003, Page 28], "a causal loop is a conceptual tool which reveals a dynamic process in which the chain effect(s) of a cause is/are traced, through a set of related variables, back to the original cause (effect). Once a group of variables has been linked together in a connected path, this forms a causal loop"

Building a Dynamic Model

This is done by converting the causal loop diagram into stock and flow diagrams, which is a formal quantitative model of the problem in question. The mathematical relationship between and among variables is then defined.

Design of a graphical user Interface

Designing an intuitive interface for IT managerial decision making requires significan research effort. For example in an earlier papers Williams, [2000]; [2001a/b], and [2002] proposed and developed a prototype research flight simulator resulting from the application of Dynamic Synthesis Methodology to the modelling and analysis of requirements engineering process. This RE process system dynamics model, whose interface is illustrated in Figure 2 below predicts the performance of the RE process in terms of cost, quality of specifications and schedule of the RE projects.

As illustrated in Figure 2, a requirements engineer or manager who uses DYNASIS can evaluate the completeness, consistency and accuracy of the model in predicting RE process performance against known performance measures as well as gain requirements engineering planning and control expertise through training with tool [Williams, Hall and Kennedy, 2000; Williams, 2001a/b]. Such a prototype can be a basis for developing flight simulators for IT managerial decision making

Fig. 2: Main Interface for DYNASIS Tool
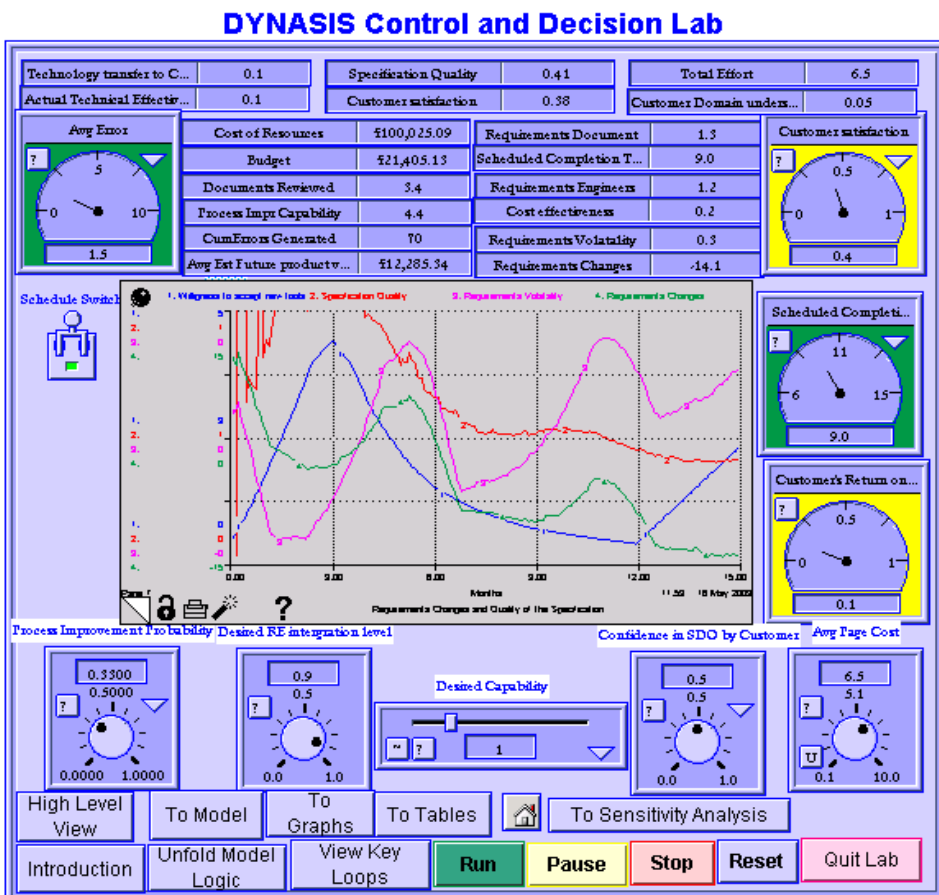
6. Conclusion and Future Work

The paper indicates that the high turnover rates at the senior levels of the IT organization the managers' ability to handle both management and business issues are a big strain on IT managers. It has been suggested that the findings of research on managerial decision-making may be relevant in IT but that research needs to be carried out on the factors that influence the decisions of IT managers in order to develop an effective "flight Simulator". The paper argues that a systems thinking/ systems dynamics approach is necessary for developing flight simulators as learning environment for managers. The advantage of SD is not merely that it captures the complexity of decision-making processes; it also offers a way of exploring the impact of change on decision-making over time. The paper describes the model, identifies a number of propositions that can be derived from it and suggests how these may be tested empirically through a flight simulator.

   The practical applications of the model are promising for both theorists and practising managers. The direction of future research will focus on validating the model and to develop a range of flight simulators for IT and other managers to improve their decision-making processes and decision-making effectiveness.

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