

An extended Taxonomy of System Dynamics Models of Higher Education

Michael Kennedy

Information Management and Modelling Group
School of Computing, Information Systems and Mathematics
South Bank University
Borough Road, LONDON SE1 OAA, UK
Tel: (+44) 020 7815 7416; Fax: (+44) 020 7815 7499;
E-mail: kennedms@sbu.ac.uk

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Abstract

A number of papers have been published describing various System Dynamics (SD) models of Higher Education (HE) institutions and issues, on topics including External forces, Corporate Governance, Planning, Resourcing & Budgeting, Human Resource Management, Teaching Quality, Teaching Practice, Microworlds and Enrolment Demand.

This paper builds on a previous paper that provided an initial catalogue and classification of this work in order to highlight potential areas of research in this field of study and to identify system archetypes at different hierarchical levels and discover new ones. This paper therefore presents an extended taxonomy of System Dynamics Models in Higher Education.

This paper builds on the initial taxonomy by widening the scope of the survey of completed investigations in higher education management. The findings from these investigations are briefly described. The taxonomy classifies the completed investigations into eight specific areas of concern and five hierarchical levels.

1. Introduction

Building on earlier publications in this area (Kennedy 2000a), the objective of this paper is to facilitate and structure debate on the use of system dynamics (SD) (Forrester 1961) for Higher Education (HE) management. Universities are continually evolving to meet government, employer and student needs, hence the emergence of new management problems (Kennedy and Clare, 1999). Higher education has been facing a series of changes with legislation and changes in government policy as one the most important driver. Due to the difficulty in managing complex environments the whole picture in terms of developing interventions is difficult to interpret. The impact of various external interventions and strategies adopted by institutions to manage and control factors is difficult to evaluate and to observe the impact on the system as a whole has been problematic.

To guide management decision making statistical linear models and spreadsheets are widely utilised. We have contended (Kennedy and Clare, 1999) that these essentially static modelling approaches are inadequate for this application domain because universities are dynamic, complex, non-linear systems. However, system dynamics methodologies have sought to redress this problem and find ways of encapsulating problem domains to assess the impact of various interventions on the system and its outputs.

Such a system can be 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. I therefore believe SD to be an appropriate modelling technique for higher education management (Kennedy 2000a). A number of SD practitioners have addressed some of the problems of higher education management and the findings from their investigations are outlined in section 3 below. The increased interest in this field is indicated by the holding on an international seminar on 'Using System Dynamics as a Tool for Decision Making in Higher Education Management' in June 1999 at the Royal Society, London and South Bank University, under the auspices of the Society for Research into Higher Education (Kennedy, 2000b). Finally, I present in section 5 below some future suggested areas of research for SD in higher education management.

2. An initial Taxonomy of System Dynamics Models in Higher Education

The extended Taxonomy is based on a survey of completed SD investigations in higher education management and other (non SD) papers that examine HE policy issues. The findings from these investigations are catalogued and classified below and briefly described in section 3. The non-SD papers are shown in italics. A more extensive summary of the work that was included in my initial taxonomy may be found in Kennedy (2000a). Some comments are reproduced from the earlier paper in order to give a better coverage of the area.

The completed investigations are classified into eight specific areas of concern and five hierarchical levels. The eight areas of concern comprise the six areas from the initial taxonomy (Corporate Governance, Planning, Resourcing & Budgeting, Teaching Quality, Teaching Practice, Microworlds, Enrolment Demand) and two new areas: External forces/ legislation and Human Resource Management Dilemmas. The five hierarchical levels comprise National, Regional/ State, University/ Institute, Faculty and School/ Department. Some work spans more than one category.

| | | Hierarchical Level | | | | |
|---------------------------------|---|---|---|---|---|---|
| | | National | Regional | University | Faculty | School |
| | External forces & legislation | | | <i>Green (1994), Mackintosh et al (1994), Gornitzka & Maasen (2000), Robertson (1999)</i> | | |
| | Corporate Governance | | | <i>Saeed (1996), Saeed (1998), Kennedy and Clare (1999), Watson (2000),</i> | | |
| | Planning, Resourcing & Budgeting | Galbraith (1982) Galbraith and Carss (1989) Bell et al (2000) | Frances (1995, 2000) | Galbraith (1989, 1998a, 1998b, 1998c) Barlas and Diker (1996, 2000) Kennedy and Clare (1999), Vahdatzad & Mojtahedzadeh (2000), <i>Mackintosh et al (1994), Davies (1997)</i> | Kennedy and Clare (1999), <i>Mackintosh et al (1994)</i> | Kennedy and Clare (1999), <i>Mackintosh et al (1994), Vahdatzad & Mojtahedzadeh (2000)</i> |
| | Human Resource Management Dilemmas | | | <i>Shattock (1999, 1997), Lewis & Altbach (1996)</i> | | |
| Specific Area of Concern | Teaching Quality | | | | | Kennedy (1998a) Kennedy (1998b) |
| | Teaching Practice | | | Frances (2000) | | Roberts (1978) Saeed (1990) Saeed (1993) Saeed (1997) Frances (2000) |
| | Microworlds | | | Barlas and Diker (1996), Barlas and Diker (2000) | | |
| | Enrolment Demand | | Jordan (1992) Frances et al (1994) Frances (2000) | Frances et al (1994) Frances (2000) | | |

Table 1: Classification of SD work in Higher Education Management

3. System Dynamists' Work in Higher Education Management

A number of system dynamicists and others have examined some of the problems with the higher education management domain. I shall briefly describe a selection of completed investigations and key findings.

3.1 External forces/ legislation

Green (1994)

Diane Green (1994) stresses that since the mid-1980's, public interest in & concern about quality & standards has been intensified by the increasing attention given by successive British Governments to reforming higher education. The reasons for this concern are:

- Rapid expansion of student numbers against a backlog in public expenditure.
- The general quest for better public services
- Increasing competition within the educational 'market' for resources & students
- The tension between efficiency and quality

Managing institutions of Higher Education is a complex task in maintaining their effectiveness. Institutional managers have a crucial role to play in relation to quality in the following ways:

- Finding ways of using the institutions resources to better effect & generate more resources
- Being accountable to the wider society, through use of effective means of assuring academic standards
- Developing improved systems of strategic planning & institutional management.”

Mackintosh et al (1994)

Mackintosh et al (1994) discuss the issues that are impacted on Higher education as a result of the public sector reforms. They analyse management & decision making dilemmas in the new concept of 'hybrid' organisations- that is, organisations providing tax supported services that are reliant on income from commercial markets. It is their assertion that these can be modelled “as operating on a dual logic, driven by quasimarket pressures on the tax-supported side, and by private market pressures elsewhere.”

This has implications for the “nature and quality of outputs of teaching and research, and for the costs, working conditions and management strategies of universities.”

The reforms themselves are moving away from budget allocations to public service providers contracting for specified tax supported services. Mackintosh et al (1994) label these as quasi-market (i.e. the public service contracting and competition as most purchasers are government bodies or professional intermediaries rather than the final users).

The reforms were based on a belief that producers in the public and private sector realms will try to provide as little as they can get away with for the maximum return they can secure (Saunders & Harris, 1992, pp62-63)

This is more complex in the public realm in the public realm as the motivation of providers includes both social and ethical objectives. The cost cutting nature & profit seeking of reforms therefore potentially have the impact of providing poorer quantity services. Organisations in the public sector are also experiencing pressure to generate increasing proportions of income from tax sources.

Mackintosh, et al (1994) outline the diversity of responses from the reforms- that is: income sources vary, e.g. proportion of income sources vary, e.g. proportion of income from grant & home rate fees from 65.7% (Bradford) to below 45 % (LSE). Other universities had substantial proportions from the sale of services (Salford & Lancaster) to those relying more heavily on research grants, such as Oxford, Cambridge & Imperial) & those that relied on overseas student recruitment for total institutional income, e.g. LSE & Essex.

Higher Education managers have a major discretion in the implementation of strategies in response to current complex incentives. Mackintosh et al (1994, pp 343) outline the hybridisation as typically generated by a unit cost & investment squeeze on the tax funded services. Thus the total quality & staff morale is threatened by the falling unit of resource: “declining tax funding per student, and deteriorating buildings and equipment. Income generation is then opted, for example:

- Charge a top-up price to make tax-financed service viable, e.g. top-up fees for students;
- Sell’ the same service in two markets, for example, differing charges to home and overseas students [...], using higher education campuses for commercial purposes in vacations; or research work priced nearer to consultancy rates by higher education research institutions;
- Create a higher quality or a wholly new product for higher price commercial sale, e.g., new short courses for overseas students, or for higher paying local students such as professionals; self-financing postgraduate teaching; a switch from research to consultancy.”

The pressure is then focused on the private markets, e.g. falling unit costs by increasing student/staff ratios. Within the private profit seeking elements, organisations have restrictions on how income can be generated. Common strategies include short courses, full cost courses in business & professional training, consultancy, publishing & internal profit centres.

Competing pressures emerge for interaction between the tax- based & private hybrid activity. For example, those with limited tax financed incomes seek to maximise this for commercial income generation. This then increases the need for scrutiny. Mackintosh et al (1994) conclude that increased mutual dependence means “the management problems of an increasingly divided organisation cannot be solved by a simple division into two commercial and non-commercial parts [p344].

Mackintosh et al (1994) identify 4 dilemmas:

- If the main tax funded services are the core activity of the organisation- how far will they allow the quality to fall?
- If the commercial elements of the HE are allowed to dominate then management time & effort become focused on marginal sums.
- How much cross-subsidy is provided by the commercial to the tax-supported activities? How does the reinvestment get made between the two elements of the hybrid organisation?
- Can the commercial element float away? The commercial elements of the organisation may seek greater autonomy, although they are still dependent to some extent on the host organisation.

Gornitzka & Maasen (2000)

Gornitzka & Maasen (2000) have outlined the pressures on Higher Education to “ ‘modernise’, ‘adapt’, ‘diversify’, ‘marketize’, it is expected to become more ‘entrepreneurial’, ‘competitive’, more ‘efficient’ and more ‘effective’, more ‘service oriented’, and more ‘societal relevant’, while it also has to improve the ‘quality of its processes and products’, its relationship with the labour market’, and the ‘governance and management’ of its institutions, the universities and colleges [...]” (p217).

As the socio-political pressures increase there is also a corresponding reduction in funding that has culminated in the “demand overload”. “Many actors pour their (regularly changing!) demands in an almost constant flow on higher education and expect a rapid and fitting reaction. But are universities and colleges capable of reacting adequately? Do they have the structures, cultures, mechanisms, human and other resources that allow them to transform in the way and pace expected?” (p217). Moreover, Gornitzka & Maasen (2000) challenge what the capability of universities is on meeting these future challenges to change and the research necessary on the dynamics of higher education. They quote a study by 30 researchers from 8 different countries- including the UK, of examination of organizational change in response to or interaction with other governmental policies and programs. The study called HEINE sought to explore the relationship between higher education and the economy.

Robertson (1999)

Robertson (1999) outlines the policy consideration of the Dearing report. The report outlined the major repercussions for management of higher education. He considers that policy maybe temporary as “...in the light of the national inquiry’s advice, Government could be firing up the process again in two or three years time.”

3.2 Corporate Governance

Saeed (1996, 1998)

Khalid Saeed (1996) investigates the dynamics of collegial systems in the context of developing countries. He states that collegial organisations consist of groups of professionals creating intangible products or services. A university is a typical example of a collegial system. While Saeed states that the model is applicable to many of the academic and research organisations established in the developing countries, in my opinion much of the analysis is transferable to other economies.

Saeed (1998) considers the rather wider topic of “Maintaining professional competence in innovation organisations”, but this paper is also relevant to HE management.

Kennedy and Clare (1999)

Kennedy and Clare (1999) examine the debate between the "managerialists", favouring strong central direction and the "collegiumists", who see the university as a community of scholars. They also identify the HE Stakeholders & Customers. They argue that the stakeholders of a university fall into the four distinct groups (Clare, 1995) of students, employers, the Government and the wider community. Each institution has obligations (although it may not have realised them) in the areas of access to the facilities, contribution to the wider academic community, providing services to the international community and the welfare of society in general.

Watson (2000)

Watson (2000) discusses the nature of management in the University environment and draws parallels with the management of other public sector institutions. Watson (2000) cites a seminal paper by Rittel and Webber (1973) to explain the slushy nature of policy development: “The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature the nature of those problems. They are ‘wicked’ problems, whereas science has developed to deal with the ‘tame’ problems. Policy problems cannot be definitely described. Moreover, in a pluralistic society there is nothing like the indisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningful correct or false; and it makes no sense to talk about ‘optimal solutions to social problems’ unless severe qualifications are imposed first. Even worse, there are no ‘solutions’ in the sense of definitive and objective answers Rittel and Webber (1973).

Watson (2000) also highlights: “In many sectors- especially the public service in general, and education and higher education in particular- it is associated with perceived loss of personal professional control and the ‘new managerialism’...”

3.3 Planning, Resourcing & Budgeting

Galbraith (1982, 1989, 1998a, 1998a, 1998a) (Galbraith and Carss, 1989)

Peter Galbraith in an extended series of papers (Galbraith (1982, 1989, 1998a, 1998a, 1998a) (Galbraith and Carss, 1989) has investigated the impact of managerial policy on HE institutional performance, with particular emphasis on time delays between policy change and the results being evident.

Galbraith (1998a, 1998b) has identified many positive and negative loops in Queensland University. An example of a positive loop is the process by which an increase in enrolments provides additional resources, which supports an increase in academic staff, which provides for the enrolment of more students, which produce additional resources and so on. An example of a negative loop is the process by which an increase in staff increases the salary bill, which reduces resources available to employ staff, which reduces the rate at which new staff can be appointed, which leads to a reduction in staff etc. In both of these two loops, delays of the order of years are involved before the loops are closed. The structure of complex systems ensures that they are inherently difficult to manage. As Forrester (1994) confirms:

“A problem is perceived, an action proposed, a result is expected but the result does not often occur. Symptom, action, and solution are not isolated in a linear cause-to-effect relationship, but exist in a nest of interlocking structures.”

Galbraith argues that recent pressure on the administration of Australian universities is due to government interventions, which has created tensions between the achievement of academic and fiscal goals. He has constructed a SD model to simulate competition between different schools that belong to a faculty that has limited funds. A wide range of employed and postulated policies are investigated. He demonstrates cyclic behaviour is endemic within the current climate despite the intention of managers to achieve stability. Finally, the results of the policy analysis are embedded within a wider discussion of the climate of institutional management, in which the concepts of “corporation” and “ecology” are employed as contrasting metaphors.

Key Findings

- Behavioural outcomes for a university, as for any complex system, are determined primarily by the combination of multiple interacting feedback loops that are a consequence of structural arrangements. The delays and non-linearities in the loops mean that behaviour cannot be predicted easily.
- Strategic plans serve a variety of purposes. For example, within teaching and learning contexts plans to improve teaching methods and to make assessment procedures more accountable are demonstrably worthwhile. Their impacts on university practices are direct, and the image of the institution indirect as public perceptions of changes in quality accrue over time.
- The production of separate plans for faculties, departments and schools means that pursuit of individual targets can in fact undermine the attainment of general institutional goals. If every unit succeeds with an ideal of achieving student growth in a situation where total funding is limited then some units must lose. Galbraith sees this as a version of the 'tragedy of the commons' because there exists a 'commons' or a limited resource shared amongst a group of competing units and the units dictate their own actions in order to maximise their own gains from the common resource. The common resource becomes less productive per individual demand as units work harder for less and less.
- It is argued that the culture of institutional administration, to the extent that it limits its vision to a corporate identity, lags a metaphor behind the world at large. While the world at large, including corporate interests, is moving its thinking beyond self-interested practices, to consider issues such as global warming, the replenishment of forests, and the protection of endangered species, institutional management remains locked in a competitive corporate prison. As Senge (1990) reminds us "*Few large corporations live even half as long as a person*".

As we point out in Bell *et al* (2000), although Galbraith demonstrates the usefulness of the SD technique for HE planning through highlighting its explanatory strengths, he did not work with any key decision-makers at Queensland University. This is a significant limitation of his research, because the findings, though interesting, so far have had little impact on the planning of the university. We contend it is important to work with stakeholders in order to identify the relevant problems. Moreover, model ownership must be achieved through passing verification and validation tests to the satisfaction of the stakeholders.

Barlas and Diker (1996)

The main objective of their research was to construct an interactive dynamic simulation model. The model examines a range of problems such as student growth, faculty ratios, poor teaching quality and low research productivity.

Key Findings

- Simulation experiments with graduate versus under-graduate study orientation has considerable positive effect on research output.
- If, when faced with increased enrolments, we try to keep small class sizes, this implies having multiple sections (or many elective courses) in order to satisfy the class-hour needs of the students. This in turn would mean increased teaching loads for faculty, which would make it difficult to maintain the faculty body (increased quit rates) and the potential faculty application pool ("supply") would shrink.

Kennedy and Clare (1999)

Kennedy and Clare (1999) discuss the factors that should be incorporated in a system dynamics (SD) model designed to assist in policy analysis regarding resource management issues. In a brief survey of current higher education approaches to planning they examine the problems with current methods. They argue that the problem with most input /output models are that they adopt a static, linear view. Such models thus ignore both dynamic interactions between the input /output factors and the nature of the 'transformation' taking place and are thus of little use when considering process improvement. They also examine problems in the utilisation of spreadsheets and the influence of quality/performance measures and indicators on funding.

Bell et al (2000)

Bell et al (2000) categorises their updated Holon Methodology, as a 'soft teleological approach'. They state that the underlying principle of the Holon Planning and Costing Framework is: "To identify an agreed future and to design ways of bringing it about within cost constraints"

The Holon Planning and Costing Framework combines a soft methodology (Holon) and a hard technique (SD). The Holon Methodology addresses 'the who', 'the what', 'the where' and 'the when' type questions at the current state S_0 , and generates a vision of a desired state S_1 . Additionally, this produces a relevant metrics programme, and the collected metrics can be used as dynamic behaviour patterns. The explanatory capability of SD tackles 'the how' and 'the why' type questions.

They report that the Holon Planning and Costing Framework is being applied within SCISM at South Bank University in an exploratory case study. They have conducted a review of QAA and the RAE literature to assist in the identification and labelling of the relevant holons, i.e. 'the where'. We have identified relevant academic and administrative staff, i.e. 'the who', participants in the planning process. Individual and group meetings have been held to identify the problems, i.e. 'the whats', associated with the current state S_0 of SCISM. This has led to the formulation of an agreed desired state S_1 , i.e. the vision and an appropriate metrics programme.

Frances et al (Frances (1995), Frances (2000))

See under 3.6 'Enrolment Demand'.

Vahdatzad & Mojtahedzadeh (2000)

Vahdatzad & Mojtahedzadeh (2000) uses system dynamics to explanation of the process of allocation of funding from a department that is seeking to expand with only limited resources available to it. They used system dynamics to explore appropriate policies for the sustainable development of the university.

The approached impinged on the tensions between finding ways of development of the research function without losing the quality and integrity of the school. Vahdatzad & Mojtahedzadeh (2000) identify the growth of the university of Yazd in terms of student numbers and faculty members. University resources however have not increased in the same way as the growth of the university. The research function was identified as the means by which the revenues could be increased for further expansion. There is an increased gap

between the allocated budget and the projected need. The researchers point to the development of visions for the university according to stakeholders' position, which leads to an in cohesive response to development.

Their research highlighted the limitations of the current progress of the university in terms of research and decision-making. They identified specific ways in which the university needs can be addressed. That is, by focusing more of their allocated resources on the research element to generate more revenues which other policy decisions regarding the university need to follow.

Mackintosh et al (1994)

New management accounting information systems are being created with increasing importance on short-term objectives that get translated into financial targets. Mackintosh et al (1994) outlines how the objectives and qualitative objectives often conflict & result in dysfunctional behaviour. They also state that 'product costing' in HE is difficult as costs are common to more than one educational 'product'. This results in the attribution of overhead costs to products being arbitrary & imprecise.

These costing problems may lead to poor allocation of resources to faculties and schools.

Davies (1997)

Davies (1997) states that: “Uncertainty and the turbulent environment calls for highly responsive and flexible policies and procedures, especially in terms of academic programmes, admissions and personnel...The interpretation of environmental signals becomes and institutional role of key significance, and the design of diagnostic and early warning devices of stresses to come is critical” [p131]

Davies (1997) produces that following table of categories of financial reduction in universities

| Category | Most common causes | Characteristic institutional response |
|---|---|--|
| 1. Slowed institutional growth; possibility of contraction | Externally imposed fiscal constraints, e.g. recession, government spending limits Stable enrolments or decline in enrolment growth rate Inflation above rate of budget increase | Efficiency measure Deferral of planned programmes and buildings Institutional self-study Increased student market efforts Increased fund raising activities |
| 2. Moderate, “temporary contraction | Externally imposed budget cuts High rates of inflation Decline in enrolment | Increased efficiency and productivity measures Some staff development/ redeployment Deferral of certain types of expenditure (principally one-time cuts) Programme reviews as basis for selective cuts Intensified student marketing and fund raising activities Early retirement policies |
| 3. Substantial contraction over relatively short time | Fiscal crises, e.g. severe recession or depression or fiscal solvency Sharp decline in enrolments Reorganisation/ merger of institution | Crisis personnel policies; redundancies redeployment Suspension of capital expenditures Intensive mission/ programme studies Closure of units and courses Explicit personnel and resourcing policies |
| 4. Long term contraction | Permanent state of uncertainty surrounding institutional viability Organisational, political or economical entropy | Programme closures Heavy focus on personnel policies Planned disposal of assets Institutional mergers |
| 5. Relative contraction in finances, and expansion in demands | Government driving down unit of resource Separation of teaching and research funding Mass HE and lifelong learning Value for money demands of universities Quality | Intensive academic and financial evaluation: indicators Efficiency drives Personnel contract revisions Programme closures Reform in teaching and learning methods Multiple income sources Intensive marketing for new students, new business: home and overseas Entrepreneurial ethic dominant: competition Restructuring Mission diversification |

3.4 Human Resource Management Dilemmas

Shattock (1999)

Shattock (1999) “The accompaniment to the rapid rise in student numbers was a very sharp fall in actual & planned unit costs. In UK terms, this is manifested itself of course in a considerable worsening in the student/staff ratio with all its attendant problems & need for adjustments in teaching arrangements, & an inability to invest in the academic infrastructure—libraries, equipment & buildings, including teaching rooms— to match the increased numbers.” [p11]

Shattock (1997)

Shattock (1997) “The impact of ‘massification’ has become much more evident: first, in the rising costs of higher education [...]; second, the increasing tension over the preservation of research excellence within mass higher education systems; & third, the structural questions of how institutions & the state should seek to cope with a growth in expectations which may produce an age participation rate of at least 50 per cent by 2010 in nearly all the advanced industrial nations. It has certainly become clear that a modern state which is both seeking to hold down public expenditure & make provision for the growth in the size of its economically non-productive population (i.e. the elderly), for the costs of health provision & for social welfare generally, cannot afford to fund the mass higher education system that it encouraged into existence.” [p27-28]

Lewis & Altbach (1996)

Further impacts on university personnel have been researched by Lewis & Altbach (1996). They comment on the Carnegie International Survey of the Academic Profession, as there is a rising tension between academic faculty staff & administrators. This has wide repercussions on the future of higher education in the context of governmental legislative constraints and pressures that HE is under for change.

The survey found that internationally academics are satisfied with their careers in spite of dissatisfaction with their academic life. Lewis & Altbach (1996) cite unhappiness with their institutions & poor leadership. Academics feel that budgets should move directly on academic functions. There is an apparent loyalty that is felt towards their academic fields but not the institution as a whole.

Academics are also reportedly unhappy about the bureaucratisation in HE. Governance structures have become more hierarchical. Most feel that they have influence on decision-making within their academic departments but not within the organisation as a whole on an institutional level. There is a general marked distrust of administrators. A high proportion of academics from the international research sample reported an autocratic governance structure with a lack of their involvement in decision-making. However, the researchers cite evidence from the sample that academic staff don’t wish to take on more responsibility in administration as these potentially interfere with their teaching and professional commitments.

Lewis & Altbach (1996) attribute this to the financial burden of HE that contributes to faculty unrest. Generally there is deterioration in working conditions:

“ Generally, classes are getting larger, there is pressure for academics to teach more, funds available for research are declining, and salaries are not keeping abreast of inflation. There are

signs that the morale of the academic profession is beginning to be sapped. Academic administrators, who must say “no” more often, are obvious and easy targets for those feeling exploited and unappreciated.” [258].

There is a reported decline in the autonomy of the institution as there are more calls for accountability and the growing need to change in line with legislative reforms, in addition to the pressure to reduce expenditure and centralize decision-making:

“Universities worldwide face a dilemma. There is near universal trend toward more emphasis on teaching, demands that faculty members account for their activities with assessment as a means of measuring the effectiveness of academic effort, and a growing societal unease with traditional ideas of university autonomy. These trends have gone furthest, perhaps, in England, where our survey makes it more transparent that faculty morale has plummeted, and alienation is widespread.” Lewis & Altbach (1996) [p258].

3.5 Teaching Quality

Kennedy (1998a, 1998b)

The information management and modelling research group (IMMaGe) have developed an initial SD model to examine quality management issues facing the school of Computing, Information Systems and Mathematics (SCISM) at South Bank University. Interviews were conducted with academic members of staff to guide the construction of the model. This investigation is considered to be the first part of a long-term project.

Key Findings

- The identification of sectors, *e.g.* Administration, Staff Performance, Department Effectiveness, Funding, Research and Funding, needed to be considered for a future quality management model.
- The identification of metrics (or performance indicators) needed to be collected for further SD investigations.

3.6 Teaching Practice

Roberts (1978)

Roberts (1978) examines student performance in the elementary classroom.

Saeed (1990, 1993, 1997)

Saeed in a series of papers has investigated the role of System Dynamics in developing teaching practice in a number of academic disciplines, including social sciences generally (Saeed, 1990), economic development (Saeed, 1993) and for a “New Liberal Education” (Saeed, 1997).

In these papers Saeed points out that (unlike the teaching of engineering and physical sciences and many of the fine arts), experimental learning is rarely incorporated into the teaching of social sciences. He asserts that this is unfortunate “*since experimentation with relationships, whether in a laboratory or a studio, helps not only to corroborate theories and create robust designs, but also to develop the reflective process critical to the creation of innovation in various professions*” and shows how SD is suited to experimentation with relationships (Saeed, 1990). In relation to teaching practice for “New Liberal Education” (Saeed, 1997), he

examines how Kolb's model of experiential learning can be implemented through the use of System Dynamics as a Technology.

Frances (2000)

In this paper Carol Frances introduces the important topic of assessing the impact of new educational technology.

3.6 Microworlds

Barlas and Diker (1996, 2000)

The main objective of Barlas and Diker's (1996, 2000) research was to construct an interactive dynamic simulation model, on which a range of problems concerning the academic aspects of a university management system can be analysed and certain policies for overcoming these problems can be tested in a "Microworld" format. More specifically, the model focuses on long-term, strategic university problems that are dynamic and persistent in nature, such as growing student-faculty ratios, poor teaching quality, and low research productivity. The model generates numerous performance measures about the three fundamental activities of a university, namely, teaching, research and professional projects. The interactive decision variables of UNIGAME are: New Graduate Students, New Under-graduate Students, Graduate Faculty Hiring Decision, Under-graduate Faculty Hiring Decision, Share on Official Projects income per Faculty Member and Weekly Release Time per Graduate Faculty Member.

The purpose of the simulation model is to investigate the difficulties of keeping the delicate balance that must exist between education, research and service and what measures can be taken to alleviate the potential problem. The validity of the model is tested using 1983-1997 Bogaziçi University data. In the "participatory" (gaming) version of the model (which starts in 1993), certain decisions are made by a "player" interactively during the simulation. The different decision making units of the universities can potentially use the model, especially in strategic planning.

Key Findings

- Simulation experiments with graduate (versus under-graduate study) orientation shows that graduate study can have considerable positive effect on research output, provided that it is coordinated with other related decisions such as instruction-hour requirements, research recognition and rewards etc.
- If, in order to obtain improved teaching quality, we keep class sizes too low, under the condition of high student enrolments this may mean multiple sections (or too many electives). This, in turn would mean increased teaching loads, which may cause serious problems in maintaining the faculty body, because of decreasing faculty supply and increasing number of faculty quit rates.
- The simulation model demonstrated the systemic nature of university management in the sense that a single decision in isolation may yield counter-intuitive results, if not coordinated with a number of other related decisions.

3.7 Enrolment Demand

Frances et al (Jordan (1992), Frances et al (1994), Frances (2000)

Carol Frances and co-workers [Jordan (1992), Frances *et al* (1994), Frances (2000)] have reported on several interventions by constructing system dynamics models to improve planning and budgeting for higher education, both to inform public policy /State Management [Results from Arizona], and to inform university wide policy [Results from Houston, Texas]. She has also reflected on wider issues in other papers (Frances, 1995).

A SD model was constructed for the Arizona Board of Regents. The model was used to examine student enrolment demand over a period of 20 years. Further modelling work was conducted with the University of Houston System investigating strategies for generating new enrolment demands amongst Houston's Hispanics and African American populations.

Key Findings

- If a system is on a slow-growth path, it may be very difficult to alter the course of that path, but SD can help identify the areas where policy or management changes have the potential of being most effective in producing desired results. Additionally, counter-intuitive patterns are frequently discovered. Multiple sub-systems interact over time to generate results that are often beyond the causal observers' ability to project.
- Another insight gained from the sensitivity analysis using the models is that when wrong decisions are made and, for instance, the financial situation of an institution deteriorates, reversing the decisions does not immediately restore the previous financial conditions. These findings accord with those of Galbraith.

3.8 Other Higher Education Contributions

Radzicki, Winch and Boucher have developed SD models in higher education management and (at present) this proprietary work remains unpublished. However, Winch and Boucher hope to publish materials based on their work for Higher Education Funding Council for England (HEFCE) in due course

4. Why System Dynamics

The dynamic and unstable nature of the university environment leads to difficulties in the management of the system. The SD approach allows for the decision-makers or other stakeholders of the model to experiment with various factors and variables included in the model. This allows the assessment of the impact of certain policy decisions prior to their implementation. Without the use of these models it is difficult to predict the outcomes of certain policy decision without actually implementing decisions prior to assessment of their impact. This allows for, amongst other things risk minimisation.

In our previous work (Kennedy and Clare, 1999) we have suggested that the potential combination of SD to IS/IT HE management appears to lie in three areas:

- Replicate existing models developed originally using other modelling styles or techniques
- Produce SD models of some of the issues mentioned in this paper.
- Develop models showing HE management processes before and after a proposed process change. At present assessing the impact of new educational technology is of particular importance (Frances, 2000).

Bolland & Fowler (2000) suggest, "...a fundamental framework based on systems theory should underpin management initiatives such as performance improvement, using the

terminology and tools of “systems thinking”. This potentially provides clarity of process, structure and method which can help to focus perceptions with respect to issues such as the polarity of causality (distinguishing cause from effect), the dynamics of policy formulation, appropriate implementation of controls and the promotion of understanding with respect to the overall complexity of the organisational situation generally.

Furthermore, “Public sector management occurs within a complex system involving several nominally independent stakeholders, coupled with informational and resource flows and behaviour that is characterised by inertia and multiple feedback loops. It is therefore apparent that the generic principles of systems thinking and system dynamics potentially provide a useful framework within which the issues of performance measurement, performance indicators and improvement initiatives should be considered...”

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