

Theory and Practice of Educational Innovation through Introduction of Problem-Based Learning in Architecture*

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Engineering education is confronted with the necessity to innovate the curricula, to meet the challenges of the next century. In many places the introduction of problem-based learning (PBL) is contemplated as a serious option. The paper reviews experience with the introduction of PBL at the Delft Faculty of Architecture in the Netherlands and the Newcastle Faculty of Architecture in Australia. Actual developments in both cases are related to theories of educational innovation and theories of organisational change and management. The objectives of innovation and the conditions for innovation management were significantly different, resulting in a different process of change. It is concluded that both faculties were successful in incorporating PBL in a strategic approach to educational innovation.

INTRODUCTION

THE PROCESS of educational innovation starts at the point when a critical mass of people are sufficiently motivated to initiate change that the inertia of not changing is overcome. When the motivation is sufficient to overturn a complete curriculum a complex process of change is put into action, and the outcome cannot be accurately foreseen. Hindsight allows us to see the change as it happened in the two cases presented here and the numerous adjustments which had to be made in the process. Hindsight also allows us to see theory and practice mutually influencing each other in the process. In this paper the introduction of problem-based learning (PBL) at the Delft Faculty of Architecture in the Netherlands and the Newcastle Faculty of Architecture in Australia will be reviewed. These two schools are on opposite sides of the world, and are opposite in terms of scale: Delft has 2400 undergraduates; Newcastle has 300. This extreme difference in scale created significant differences in the approaches to change, the types of change which occurred and the outcomes in these two highly regarded schools of architecture. Actual developments will be related to theories of educational innovation and theories of management and organisational change.

BACKGROUND TO THE DELFT, FACULTY OF ARCHITECTURE, NETHERLANDS

In the 19th century students in civil engineering could graduate as architects at the Delft University

of Technology (at that time the Delft Polytechnic). In 1905 the Architecture department branched off from the department of Civil Engineering. The architecture curriculum of the early years showed the inheritance of civil engineering, with technical and theoretical disciplines emphasised and little provision for design teaching. During the next decades, the artistic components gradually increased in importance in the curriculum until, in the thirties, the 'Delftse School' became recognised as a distinct movement in architecture. Teaching methods from the tradition of the French 'Beaux Arts' were mixed with the methods of engineering education. Since then, the balance between these two influences on teaching in architecture has been swinging back and forth like a pendulum.

At the end of the 1960s the architecture curriculum was completely overturned with the introduction of project teaching, characterised by principles which reflected the social ideals of the democratic movement of the time. Those principles were: learning should be relevant in a social context; students should develop independence; and teaching should be non-directive [1]. Within the project teaching approach teachers were able to express their personal convictions and preference of architectural style, so traditionalism, functionalism, constructivism, deconstructivism, realism, and post-modernism were all represented. The independent position of the teachers, however, prevented ongoing central guided development and refinement of this approach. Ongoing debate about the quality of education was part of the culture, and overall planning could be ignored in favour of individual

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philosophies. At times internal criticism resulted in ambitious plans to improve the curriculum, however the system gradually deteriorated and the general cohesion within the curriculum was lost. Some subjects were duplicated by different teachers, other areas were neglected and, eventually, the students' freedom of choice was reduced to choosing a project mentor. Eventually, too, criticism of the Faculty of Architecture from outside culminated in a negative report from a national review committee [2] which concluded that technical study areas were neglected and the curriculum lacked cohesion. The resulting political climate threatened the sheer existence of the faculty.

In order to survive, the Faculty Board initiated a major programme of curriculum innovation. An internal committee of professors was appointed to design a new curriculum. The committee, with support from educational advisors from the Limburg State University, produced a proposal to renovate the entire curriculum, with the introduction of problem-based learning (PBL) as the didactic principle [3]. The general purpose was to improve the performance of the program, with knowledge from different study areas and design skills integrated in the new curriculum in conformity with PBL principles. The plan generated widespread debate, but 'something had to be done'. The Faculty Council therefore reluctantly accepted the proposal and the plan to introduce PBL was implemented barely half a year after the presentation of the PKB report, with the first students starting in the new curriculum in 1990.

BACKGROUND TO NEWCASTLE, FACULTY OF ARCHITECTURE, AUSTRALIA

Architecture at Newcastle grew out of a technician's course at the Newcastle Technical College. In the early 1960s a small university college was set up in Newcastle in the form of a branch of the University of New South Wales (UNSW) located in Sydney. Architecture became part of the college and changed from a technician's course to a full professional course which was a clone of the architecture course at UNSW. By 1970 the logistic problems of running two campuses and parallel courses one hundred and fifty kilometres apart were accepted and the college became an independent provincial university. Architecture was given faculty status, although it was the smallest faculty in the university and one of the smallest in Australia.

The new faculty set out to do things the way they were done in larger faculties, particularly Faculties of Architecture in the larger universities. A high profile practitioner was appointed Dean and the new faculty set out to emulate the top schools of architecture. The pedagogical approach and five-year curriculum, with a two-tier degree structure, from UNSW were maintained, with similar disciplines, and some ambitious research was initiated to reinforce the big-faculty

aspirations of the new faculty. Newcastle was not a big faculty, however, and struggled to maintain all the distinct disciplines which were found in the larger faculties. It also struggled to maintain a high profile practitioner as Dean: the Dean led the discipline of architectural design, and had to maintain a substantial teaching load in order to sustain the design discipline. Competition with the demands of a high profile practice, however, resulted in decline of teaching in design which is the central and most important aspect of any architecture course. This also resulted in lack of leadership as the Dean was absent for much of the time, leading to dissatisfaction among the staff and students. The Dean subsequently left and a new Dean was appointed from the teaching staff.

The faculty continued to languish, however, as it could not sustain the traditional structure with specialists teaching only in their particular specialisations. Staff dissatisfaction led to student unrest, which contributed to a negative morale syndrome and to difficulties with accreditation, exacerbated by loss of students to other courses. At this time the university was under pressure to reduce the number of faculties and decided to close the smaller faculties, with architecture to become part of the large Engineering Faculty. The architects' profession in Newcastle reacted very strongly to this, and lobbied the university to take a different approach. The value to the region and the profession of retaining the faculty was demonstrated, and the opportunities to turn the smallness and provincial location of the faculty from liabilities to advantages were established.

The presence of the new medical school (started in 1976) with its successful adaptation of an innovative problem-based learning approach provided an 'incubatory' environment for architecture to try a similar approach, and the smallness of the faculty allowed some experimentation which could not be undertaken in larger faculties, particularly in the larger cities where intense competition between schools of architecture made them very conservative. The eventual retirement of the second Dean provided an opportunity to appoint a new Dean with the particular qualities of an 'agent of change' rather than the conventional qualities of eminence in practice. This and the commitment of the faculty to a new approach were interactive and debate continues about which occurred first. The strongest evidence is that the commitment to change occurred when the profession convinced the university to retain the faculty, and that the criteria for selection of a new Dean as an agent of change flowed from that commitment. The role of the Dean, therefore, was one of facilitating and guiding change rather than of initiating it. The Faculty of Architecture launched itself into an ambitious programme of innovation which was to lead to it becoming a leading school in Australia, with an international reputation for excellence and educational innovation.

ABOUT PROBLEM-BASED LEARNING

Architectural education throughout the Western World is dominated by 'studio teaching' which varies between what educationalists might refer to as 'tutorial-based teaching' and 'apprentice-based teaching' or mentor-based teaching. Donald Schön [4] recognised the integrative value of studio approaches as models for other professional education. Ironically, however, while architectural education is characterised by this ideal of integrative learning, and this accounts for the all-important design teaching, the majority of architectural education is characterised by 'dis'-integrative teaching, in individual subjects with little connection between them.

Notwithstanding this entrenched dichotomy of educational approaches, the espoused philosophy and holy grail of architectural education is integration of all curriculum with the design process. Problem-based learning (PBL) gives a name and an established body of theory to a form of education which embodies the best characteristics of traditional design teaching and allows them to be applied to the whole curriculum within a single theoretical framework, thereby achieving integration at both the theoretical and application levels [5]. PBL has been called 'the most important innovation since the institutionalisation of education for the professions' [6], however the method had been invented elsewhere and was therefore not a true innovation [7]. Nevertheless, the application of PBL represents a significant change and challenge which are innovations in themselves and can provide an environment for stimulating innovative behaviour in staff and students.

Problem-based learning as a full-scale didactic approach to a curriculum was developed in medical education at McMaster University in Canada during the late 1960s, to address criticism that medical education was removing itself from actual medical practice. Expanding knowledge within the medical discipline and the ongoing development of specialisations in practice resulted in curricula filled with details and fragments of knowledge, much of which was obsolete by the time students graduated. Adoption of PBL aimed to bridge the gap between education and practice by means of a holistic approach based on themes representing problems from medical practice. This contrasted with conventional divisions between disciplines which fragmented a curriculum into separate courses in accordance with sets of basic knowledge and specialist fields.

PBL draws on insights gained from both professional practice and educational practice including, for instance, Jérôme Bruner's concept of 'Learning by discovery' and Carl Roger's concept of 'Student-centred learning' [8]. Instead of emphasising the transfer of knowledge by teachers, PBL focuses on stimulating the students' learning process. In PBL, students are expected to define their own learning goals and to pursue actively the

accumulation of knowledge and skills. A problem from practice acts as a starting point development of a PBL problem. The main difference between practice-based problems and PBL is that PBL problems are abstracted from the reality of practice. That is, solving the real-practice problem is not the point; each problem serves as a generic problem, and the process of learning about problems and solutions to it are the salient educational agenda. Many of the problems from practice challenge experienced practitioners, and students are motivated by the experience of dealing with real practice problems, notwithstanding that they are abstracted. To this extent PBL is comparable with project work, case studies and studio teaching approaches.

Problem-based learning is an educational philosophy of the post-modern era [9] and is successful, particularly in professional education, in the sense that growing numbers of institutions are embracing this educational approach. At first, it was disseminated mainly in medical education, with the medical school in Maastricht (Netherlands) and in Newcastle (Australia) among the first to follow McMaster. Each of these then developed as a new nucleus, exporting PBL to other disciplines. Today PBL is applied all over the world in a wide variety of studies, ranging from medicine and architecture to law, economics, business administration and engineering and, in the process, has developed and diversified into a family or taxonomy of problem-based approaches.

The specific format varies from one application to another. In some cases the traditional lecture format is completely eliminated. In other cases lectures are employed next to problems, as one of the means to challenge students. Although group learning is not essential to PBL, in most established PBL courses learning is characteristically enhanced by small group work, where students co-operate in defining their own learning objectives. Group discussions about practice problems activate prior knowledge, and learning is cross-linked with existing knowledge, fostering the development of a thinking structure that is relevant to practice [11]. Group sizes vary from 4–5 students (as in the original McMaster model) to the size of a class. It is generally accepted that the staff members guiding the group work should act as facilitators rather than teaching their expert knowledge [12]. However, the desired level of competence for the facilitator (commonly referred to as tutor) ranges from nil content in specific expertise to broad experience in practice [13].

Despite apparent differences, all PBL approaches share some basic principles, partly didactic and partly related to their professional orientations, and application of these principles has led to some characteristics shared by most PBL versions.

Didactic principles:

- students are responsible for their own learning
- co-operation rather than competition
- active acquisition of knowledge and skills.

Professional orientation:

- holistic orientation towards professional practice
- integration of knowledge from different domains
- integration of knowledge, skills and attitudes.

It is possible to apply PBL methods in a single discipline within an otherwise traditional curriculum, however the benefits of integration of knowledge and skills from different domains favours a thematic curriculum structure. Lecturing is usually not consistent with integration and does little to encourage students to take responsibility for their own learning. The small group format therefore often surfaces as a natural alternative, with a range of interpersonal dynamics which provide opportunities for integration, co-operation, motivation and acceptance of responsibility for learning.

IMPLEMENTATION OF PBL IN THE FACULTY OF ARCHITECTURE AT DELFT

The decision to implement the innovation was basically a top-down decision, necessitated by ongoing and inconclusive debate in the faculty. The key factor which motivated the choice of PBL was the attractiveness of a high numerical efficiency in the PBL programme in the medical curriculum in Maastricht, and the Faculty Board, guided by an interim faculty director, pressed the Council to agree to the proposal. At the time the decision was made, however, the PKB proposal [3] fell far short of a blueprint detailing all aspects of the new curriculum, and a lot of planning work remained to be done.

The preparation phase was short, with the first students expected to start with the new programme about half a year after the presentation of the plan. In order to achieve this a group of co-operative staff members was selected and assigned the task of developing parts of the new curriculum. Since the thematic structure crossed the old borders of disciplines and projects the organisation structure had to be adjusted. The existing faculty organisation was traditional, with the staff grouped in discipline-oriented departments, and each department responsible for its own part of the curriculum. A shadow structure was therefore erected, based on teams (so-called block groups) of two to three members drawn from different departments. Each of these groups was commissioned to develop the program for a block theme. A linking structure of committees of co-ordinators from the block groups was responsible for co-ordinating the development of the overall basic program (the first two years) and each of the five differentiation (specialisation) programs. Co-ordination of the whole implementation process was undertaken by another committee, installed by Faculty Council, and consisting of the co-ordinators and chaired by a 'dean of education' [14].

The plan that emerged was modelled after the

Maastricht example, and represented a rough outline for the curriculum, with a thematic structure for the first two years. The programme of each year consisted of six blocks each lasting six weeks. The blocks were constructed around themes such as 'the House', 'the City' and 'the Wet Cell' and were presented in a fixed order in a 'rooftile-like structure'. The plan called for traditional teaching to be replaced by small group work, and for design projects in the first years to be replaced by limited design exercises. Beyond this general format, the architecture staff had to fill out the detailed aspects of the curriculum and its implementation [15]. Despite the attention given to curriculum planning, the philosophy of PBL was not understood by most of the faculty. Outside the circle of contributors to the plan there was only a small group of active supporters, and a majority who were ambivalent or who opposed change avoided the information meetings.

Given this resistance (or inertia), and the short preparation period, it is not surprising that many things went wrong, and even amazing that it worked at all. Only the talent for improvisation in a creative architecture faculty, made it possible. From the outset, the logistics of management of the new curriculum proved to be very difficult, and the education office was forced to change its role, from that of providing service on request to the teachers, to that of a co-ordination centre. Unfortunately, the office was unable to deal with the magnitude of the task of planning and co-ordinating such a major change in such a large organisation. Eventually, the educational program had to be adjusted in order to render it manageable, resulting in disruption of the carefully arranged rooftile-like structure of the blocks.

The drawbacks of a top-down decision were also noticeable. It was still relatively easy to persuade and recruit staff members to participate in the development of the new programme, particularly as the new status of block co-ordinator had some appeal. It was much harder, however, to attract staff members for the role of facilitator for the self-directed student groups and, despite directions to all staff to participate in tutor/facilitator training, at least 20% refused. Even those who were willing had difficulty in understanding and adapting to the changed roles of staff in the new educational method. Orientation programs and study materials for staff therefore had to be developed before the teachers were able to become familiar with PBL and before real progress could be made on programs and materials for the students. A staff member who had been designing one of the PBL blocks, asked after the tutor training if he could please redesign the block, as he only now understood what it was all about.

The real problems began, however, when former project mentors had to act as tutors. As design teachers, the former project mentors had enjoyed considerable status and independence, and the satisfaction of being chosen to pass on their

philosophies and experience to the next generation. In the new approach they had to restrict themselves to facilitating, and in a learning process which was broader in scope and included unfamiliar fields. They did not know how to behave in the new role and they did not want to know how to. The design teachers claimed they needed at least two half days a week (or rather three) to teach the students the intricacies of design and they forced adjustments to the new program before it actually started. The authority of the Board to implement the new plan was therefore challenged and found to be limited with the result that only some of the new plan was achieved. The result was a dual system, with about half the time within each block spent on knowledge-oriented study using PBL methods, and the other half reserved for design teaching. This brings the Delft course back into a line which is closer to many conventional architecture courses than intended, and closer than the former project-based approach. Ironically, both parts of the system are basically problem based, differing only in the didactics, and the system has been adopted by the faculty as the 'architecture variety' of PBL [16].

Confronted with these two didactic approaches the students tended to follow their preferences, resulting in competition for students' time between the two tracks. From the students' point of view, working on a design assignment was the real challenge and purpose, and much more attractive and relevant than the paper case studies they had to study in other subjects, particularly mathematics and structures. Most students also preferred the intensive teaching in the design track to the uncertainties of self-directed study in the knowledge track. An evaluation report after the first half year signalled the problem that students were spending much more than half their time on designing and, consequently, considerably less than the necessary time on theoretical study areas, thereby restricting the integration of different disciplines.

Notwithstanding the difficulties, a new review committee clearly appreciated the daring and the energy the faculty put into the new curriculum [17]. Many characteristics of the original PKB plan are still discernible six years after the start of the innovation process. The thematic structure of the curriculum is largely intact and the linking organisation structure is still there. The themes of the first two years are also still the same, except for minor changes such as re-naming the first block theme 'the house' as 'architectonical space', and other minor adjustments such as reduction in the number of disciplines contributing to a single block.

At the organisational level, however, little is left of the plan for faculty-wide curriculum and didactic method. The departments have gradually regained their power in the organisation, abandoning the alternative structures, or relegating them to mere formalities. The design teachers claim half

the curriculum and about 80% of the students time. Consequently, design teaching also absorbs the major proportion of resources and staff time. The design teachers have also largely reverted to teaching the way they have always done it [18, 19], ignoring the carefully prepared block program, and amending the exercises until they are effectively running their own individual courses. Teachers from theoretical disciplines have followed this example, creating opportunities to teach their own discipline separately, either in the guise of practice exercises, or in the lectures increasingly crowding the timetable of the average block. As a result the students' self-study time has been lost, as the students spend all their time with the demands of competing groups of teachers. This competition between teachers translates into overload and stress in the students as they strive to satisfy both sets of teachers, who not only teach but, significantly, also assess the study results.

IMPLEMENTATION OF PBL IN THE FACULTY OF ARCHITECTURE AT NEWCASTLE

The convenient presence of an established PBL course in the new medical school at Newcastle, right next door to the architecture faculty, was used to observe and compare and, with help from curriculum development staff of the medical faculty, a variation of the medical model of PBL was developed for architecture. A strong consensus of interested parties including faculty staff agreed that architectural education's (and the faculty's) primary objective of integration of all curricula with the studio teaching of design might be met through use of PBL. There was a strong minority of doubters, however, and it was decided to undertake a trial of the new approach in the first semester (March–June) of Year 1. At the end of the semester it would be decided to abandon the experiment, or continue into the second semester and then allow the new approach to be progressively introduced to Years 2, 3, 4 and 5 in succeeding years with the same cohort of students.

The two-tier degree structure of the course (a three-year B.Sc(Arch) course followed by a two-year B.Arch professional course) provided an opportunity to experiment also at Year 4 level, the first year of the professional course, and it was decided to attempt an even more comprehensively integrated approach concurrently, and with the same provisos as applied to the Year 1 experiment. Before the end of the first semester, however, the faculty was convinced that the new PBL approach in Year 1 was outstandingly promising and would be continued. The faculty was also convinced that the integrated learning approach in Year 4 was sufficiently compatible with the PBL approach and showed such promise that it should be further developed as a possible future successor to the current PBL model.

The faculty was also convinced that the difficulties of maintaining two different educational approaches (the former traditional approach and the new PBL/IL approaches in parallel) were already greater than the difficulties of an accelerated adoption of PBL, and it was therefore decided to change the whole course over in the following year, with Years 1–3 using the PBL model and Years 4–5 using the IL model. The course was set up broadly to create the environment and follow the processes which are found in current practice, to enhance development of the skills and *modus operandi* of architects in current practice. Particular ‘model firms of architects’ were selected and used to demonstrate the relevance of the curriculum and learning methods to the students’ future professional activities. The course structure involved real projects throughout, with real clients, both selected to provide progressive increases in complexity and scale throughout the course, from relatively simple, one-room buildings at the beginning to major CBD high-rise office/retail development later.

Projects were selected to develop particular sets of knowledge and to provide focus on particular aspects of design (e.g., exterior, interior), construction (steel, concrete, long/short span, low/high-rise) and context (rural, suburban, CBD). In general, the students were given the whole problem, with a minimum of simplification and abstraction to clarify the boundaries of ‘the problem’ and create the intended focus, for instance on skills development early in the course to complex professional development later. Traditional boundaries between disciplines and subjects were removed and re-cast so that recombined ‘study areas’ emerged, reflecting the way sets of knowledge, skills, specialisations and expertise are grouped in the real world of industry and professional practice, and allowing obsolete content to be removed and relevant new content included.

The first difficulty encountered was staff overload, particularly in Years 1 and 2, as staff were teaching in two parallel but insufficiently co-ordinated timetables, one for the old course continuing and another for the new courses as they evolved. In particular, the demands on subject specialists to service the PBL course meant a very different approach to timetabling, with co-ordinated intense workshops often being required and displacing the traditional regular lectures. Timetabling and central co-ordination therefore became the principle logistical challenge at the time. It took time, also, for staff to stop attempting to include all of the traditional content in addition to the new content.

The next difficulty encountered was student overload in both the PBL and IL programmes. Students had difficulty in adapting to the change in balance between study areas and tended to overwork on new ‘for information only’ classes and assignments as well as on knowledge-building classes and assignments [20]. Some staff, too, had

difficulty in downgrading some of their traditional curriculum to ‘for information only’ status and in embracing new material from practice required by the real context of the projects. A large group of students from South East Asia had particular difficulty as they had made one major cultural adjustment to cope with the traditional course, and were having to make another major adjustment. All students had difficulty in the shift from teacher-centred learning of the traditional course to the student-centred learning focus of the new approaches, particularly in the integrated learning course.

The change for staff was as profound as it was for students. The change in role from unchallenged expert in a narrow field to reflector of (other practitioners’) broad expertise was accommodated readily by staff who were (or had recently been) practitioners, but was a particular difficulty for career academics. The loss of authority to confine the agenda within their interests and experience, and the new need to teach and field questions in the broader field determined by each project created considerable role conflict in all staff. Some staff were unable or unwilling to adapt to the new courses and left within the first year. Others suffered unacceptable stress and left in the second and third year.

The change in staff was both advantageous and disadvantageous. An entrenched political/personal feud between two groups of staff dissolved when the key adversaries left. Staff who were disenchanted, for instance over promotions, also left. They were replaced by staff who were multi-disciplinary and with considerable experience in the profession, and who were non-aligned in relation to old feuds. The new staff also were able to adapt to the new teaching approaches without having to ‘un-learn’ the old approach. The new staff were also more highly motivated and energetic and created a positive syndrome of morale which gradually extended through the staff and students.

The new approaches have now been in place for ten years and the faculty has established itself as a leader in architectural education and in the development of teaching theory. Two members of staff received teaching excellence awards and the faculty has the highest accreditation rating of the thirteen architecture schools in the country.

EDUCATIONAL INNOVATION AND ORGANISATIONAL CHANGE

In order to understand the implementation processes described above, we can look at both literature on educational innovation and literature on organisational change. Literature on educational innovation suggests that elaborate procedures of planning and preparation are necessary to effect such a change [21–23] and that the degree of involvement of the participants is crucial to

success. That is, the more the participants perceive the innovation as instrumental to realisation of their own goals, the better the chances of success. This implies that an extended process of preparation is necessary, to involve participants and achieve their commitment to the change before actually implementing a new curriculum. Literature on organisational change, on the other hand, suggests that at times it can be effective to apply some force. Chin and Benne [24] distinguish three types of strategies that can be applied to achieve change in an organisation:

- empirical/rational strategies
- normative/re-educative strategies
- power/coercive strategies.

Each of these strategies rests on implicit beliefs about human nature. Adherents of the first strategy see man as a rational being. The second strategy emphasises the social aspects of human behaviour and the ability to learn new behaviour. Power/coercive strategies are based on a less optimistic view on human nature. People identify primarily with their personal tasks or task perceptions and most of them are blind to the advantages for the organisation as a whole. Legitimate power may therefore be exercised to protect the larger interest.

The Delft and Newcastle experiences show that all three types of strategies have been used to varying degrees in both cases. In the Delft case empirical/rationalism was presented as justification for the change, but change was forced on the Faculty (power/coercive) by external threat. The development of the new plan by a minority of staff and the unilateral decision of the Faculty Board to implement the plan was also power/coercive. The attempts to re-train staff were no doubt intended to be normative/re-educative but were apparently perceived by a majority of staff as power/coercive. Had the information sessions been offered earlier, they might have been more re-educative and more successful, and might have reduced the need for unilateral, power/coercive behaviour by the Faculty Board and the Council.

In Newcastle the external threat was clearly power/coercive, and the decision for change was no doubt largely made on a basis of some form of rationalisation of responses to the threat. The proactive support of the profession, however, allowed rationalism to be followed by self-directed re-education (at least on a consensus level), allowing the form of change to be decided by the faculty and avoiding the need for power/coercive direction from outside about the form of change to be made. The faculty members therefore 'owned' the decision and the form of change adopted. Educational innovators appear to prefer a combination of the first two strategies. They want to convince people of the rationale for change and/or re-educate them in order to persuade them to comply. On the surface this seems to be a sound approach, however convincing people takes time, and convincing

a lot of people takes a lot of time. The larger the organisation, therefore, the more conservative the people appear when considering change. Conversely, small organisations are more easily moved and therefore less conservative.

Under stable external conditions, therefore significant change in large scale educational organisations is unlikely. The use of top-down authority is therefore often considered necessary when change is imperative and urgent, as in the case of Delft. Alternatively, a catalyst can be used to disrupt the status quo, as in the Newcastle case, where a new Dean used removal of traditional disciplinary empires to disrupt the inertia of established conservative networks and authority/seniority structures. Power/coercive strategies may be successful in solving the most urgent problems, however innovation based on this approach is unlikely to be sustainable beyond the very short term. People who have been left out of the decision processes, and people displaced without the provision of a more attractive alternative, do not 'own' the decisions or the philosophies on which they are based, and will have little reason to support the outcomes. In order to effect sustainable change, it is necessary to deploy a long-term strategy, creating conditions for individual commitment as well as corporate commitment. The management devising and implementing this strategy must be sensitive to both the organisational behaviour implications and individual perceptions and aspirations, and be able to harness both in support of any proposed interventions. This means that strong educational leadership requires extensive management skills in order to achieve sustainable change.

CONCLUSIONS

The purpose of this paper is to explain the mechanisms of educational innovation. Whether the educational innovations at the Faculties of Architecture in Delft and Newcastle are considered successes or failures depends on choice of criteria for success, and both positions can be defended in both cases. The relevant issue for consideration here is how change happened.

In some respects the educational innovation in each case can be considered to have failed. Some old teaching methods have survived the change in both cases under the guise of some new labels. Stress in the early stages on staff and students, and loss of both might also be considered failure. On the other hand, most staff members are happy with the respective curricula as they have evolved, and the report of the respective external review committees have been highly supportive.

The new curriculum in each case is firmly established, as clearly demonstrated by unsuccessful attempts in each case to alter the new structure. For instance, in Delft there have been failed attempts to introduce discipline courses outside

the blocks (as advocated by the technical disciplines), and to concentrate design teaching in a few of the blocks in order to allow more time for theory-oriented study in other blocks. In Newcastle there have been attempts to re-establish a separate design discipline, and also to restrict design teaching to design specialists. Attempts to re-establish the authority of the teachers in both cases, particularly in design, over what is taught and how it is taught, have been accompanied by strong pressure for master classes. These attempts, however, are inconsistent with the objectives of integration and relevance, and are opposed in principle to the spirit of PBL.

The return to teachers for giving up their dominating role is they have the satisfaction of watching students' growing enthusiasm and independence. This form of satisfaction characterises good teachers in any didactic system. Additional satisfaction comes from high levels of recognition and accreditation, and general support from the profession for the relevance of the abilities of emerging graduates to current demands of professional practice.

PBL was introduced as a strategy for achieving organisational and educational objectives and as a means to effect change. In both Delft and Newcastle the primary organisational objective was survival of the Faculty. In Delft the educational objective was numerical efficiency and PBL appeared to offer a path to that objective. In Newcastle the objective was integration, and PBL appeared to offer an appropriate structure for achieving that objective. The reasons for choosing PBL therefore differed and the means of introducing PBL also differed. Differences in scale of the two faculties contributed to the differences, the larger faculty in Delft having more inertia and

conservatism to overcome than the smaller faculty in Newcastle.

A comparison of the two cases suggests that the process of change is not complete in either case, but that Newcastle, which started earlier, is further along the path than Delft. Newcastle staff and students have overcome the negativism which inevitably accompanies change and have developed a new confidence in the school and high levels of morale and mutual commitment. Delft started later and appears to be in mid-change, with dissatisfied staff still in the process of leaving, student overload not yet resolved, and the new confidence not yet developed. The recent appointment of a new Dean may accelerate the change, and the retirement of a significant number of senior staff will no doubt reduce the inertia of the organisation to resist change.

The prognosis for both faculties is good, even excellent. Both are highly regarded in higher education circles as model applications of PBL, and in architectural education as models of excellence in achieving educational approaches which reflect the needs of the profession for the new century. This outcome has been achieved despite the unknowns inherent in such ambitious undertakings and, in the process, has reduced the unknowns for others contemplating change of comparable scale, regardless of whether PBL is a significant part of the proposal. Extrapolation from the two cases set out here can provide bases for strategic managerial approaches to the multiple frameworks of organisational behaviour and educational innovation required to achieve sustainable change, particularly the innovative and challenging learning environments required for engineering education in the new century [25, 26].

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