

FLEXIBILITY A KEY ISSUE IN PLANNING FOR CHANGE IN LABORATORY DESIGN

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Résumé

Indiscutablement les phénomènes de changements et de croissance sont devenus des variables incontournables dans le contexte de la conception architecturale. La contention des effets d'obsolescence est impérative pour ces lieux d'enseignements. Le présent article tend à examiner d'une part les causes majeures dans la manifestation du phénomène de changement dans l'environnement bâti des laboratoires à caractères scientifiques. Et d'autre de mettre l'accent sur l'impérieuse nécessité d'inclure un potentiel de changement et de croissance ainsi que de révéler les approches susceptibles de maintenir the state of fit à un degré satisfaisant eut égard l'interface users/space.

Mots clés: Changement, Croissance, Flexibilité, Adaptabilité, Obsolescence, Laboratoires a caractères scientifiques

Abstract

The central idea of the article centres on the inclusion of a potential for change and uncertainty and subsequently to incorporate unpredictability and diversity as intrinsic parameters in the process of laboratory design. It has been argued that the diagnosis of the main instigators of change was an essential key in 'predicting, not the changes which will affect the life of a given building, but the likelihood, rate and degree of changes'. Accordingly, four major causes were identified. These include: i) growth of student numbers, ii) change in technology, iii) change in the curricula and iv) change in the activity size.

Keywords: Change, Growth, Flexibility, Adaptability, Obsolescence, Science laboratories.

**KRADA S. E. El Ayoubi
SAHNOUNE Tayeb**
Département d'Architecture &
D'Urbanisme,
Université MENTOURI-
Constantine
Algérie

ملخص

الفكرة مركزية من المادة [سنتربس] حول التضمن من احتمال لتغير وشك وفيما بعد أن يدمج [أونبرديكتيبيليتي] وتنوع بما أن معلمات جوهرية خلال مختبرة يصممون. جادلت هو يتلقى يكون أن التشخيص من أ ل [إينستيجتور] رئيسية تغير كان مفتاح أساسية في 'يتنبأ' لا التغيرات أي سيتأثر الحياة من يعطى بناية غير أن [ث.ليك] غطاء معدل ودرجة التغيرات! وفقا لذلك عيّنت حالة نمو من طالبة أرقام [إي] تغير في i: أربعة أسباب كبريات كان. هذا يتضمنون تكنولوجيا [إيبي] تغير في المنهج تعليم و [إيف] تغير في النشاط حجم.

الكلمات / مفتاحية: نه , حالة و, مرونة, قابلية, حالة بطلان, علم , ات

Introduction

'One of the most remarkable developments in the 20th century is the extension of the scope of scientific discovery'. (1) Through this 'explosive growth of science and technology has generated' important developments in terms of scientific laboratories provision, yet, argues the New Scientific laboratory design has not kept pace with laboratory activity'. (2) Motives claimed to be at the heart of this 'malaise' are twofold. The first is that 'the expertise available in the design and construction of laboratories is not shared'. (3) The second is the lack of an architect-users dialectic which stems in the main from the architect's inability 'to define, and apply the kind of knowledge needed for good design and good building'. (4)

In addition, as scientists' needs continue to change rapidly laboratory design moves into an intricate and highly specialised field. This, besides emphasising the urgency of a stringent attention over complex relationships between the various forces involved, highlights that 'if investment in laboratory buildings is to offer the optimum return, flexibility and adaptability must be central to their design and use'. (5)

This article therefore attempts first to outline the prime causes implicated in the occurrence of change in science laboratory activity. Second, to emphasis the magnitude of the task of incorporating a potential for change in the general design strategy of laboratory building in order to maintain the ability of the users to use the facility in an optimum way.

Finally, to examine current approaches whereby to mitigate the effects of change upon laboratory buildings.

2. Definition and Concepts.

Undeniably one can understand the meaning of a concept in two discernible ways. One is through the Dictionary meaning, the other is to take the contextual or physical meaning. Accordingly, the Oxford dictionary whilst defining flexibility as 'the quality of being flexible' refers to adaptability as 'the process of modifying so as to suit new conditions'. (6) This is to say that the former concept implies the inclusion of change whereas the latter indicates 'the power of adapting' or 'of being adapted'. (7) In the context of architectural design a myriad of studies investigated these concepts in an attempt i) to discern differences in the meanings embodied in these concepts, ii) to formulate ways of achieving them through physical design and iii) to postulate the extent of the relationship between flexibility or adaptability and change in activity. In this respect, Whyte has identified flexibility as the aptitude 'to provide for the simultaneous existence of order (or stability) and disorder (or diversity, randomness and change)' and thus establishing a reconciliation between conflicting polarities. (8) A similar connotation was put forward by Habraken in his theory of mass housing. The key to this theory is the 'Support' concept which refers to the hierarchical organisation of sub-systems. Its major hallmark is the separation of the structural support function

from the function of portioning, creating as a result, as noted to by Van Doesburg, an open plan which will be subdivided according to users particular requirements. (9)(10)

Lynch's idea of flexibility suggests two routes. One 'which operates in the present' is to widen the individual's choice by providing a broad spectrum of alternatives (for instance a large house with numerous rooms) while involving him in shaping his own physical environment. In Lynch's terms this is referred to as a 'plastic environment'. (11) However, equating flexibility, as identified above, with the present, while neglecting the possibility of future changes, appears rather short-sighted. Lynch's second meaning of flexibility calls for a 'generalised adjustability of an environment of artefact, with minimum effort, to future changes of use'. (12) He states that 'this might best be called adaptability'. (13) Although the locution 'with minimum effort' is debatable, as Al-Nijaidi argues, it brings to light the idea that the environment must be designed to give opportunity to the users to adjust their environment as their requirements change. Along the same lines is Moharram's definition of flexibility as 'the tendency to change in order to suit new requirements in use'. (14) To consolidate further these views is Fawcett's interpretation of adaptability as 'the ability to maintain compatibility as the activities change'. (15)

It therefore could be induced from the above explanations, that i) a schism between the meanings of flexibility or adaptability is by no means universally acceptable and ii) the essence of both flexibility or adaptability, while centring around the quality of an 'object' subject to change, deals with a situation that embodies a degree of uncertainty and unpredictability.

3. The Problem of Change.

Change has become one of the most stringing features of modern societies. It has affected almost all parts connected with human affairs. Heath stressed that 'the period of social and technical change is now shorted, often considerably shorter than the life of buildings'. (16) However, the recognition that 'structures housing the activities in most rapid flux (universities, laboratories, hospitals & offices) are in constant turmoil of destruction and change' (17) emerged in the main from studies by Cown, Weeks, E. Jones and the Laboratories Investigations Unit Team. (18) (19) (20) (21) the array of these investigations generated the most authoritative statements about the topic of change. These studies, which aimed at describing and noting the extent of change in relation to the two essential components of the built environment (space and activity) over time have i) demonstrated that buildings grow, change and become obsolete rapidly, ii) manifested the magnitude of incorporating a potential for change in the provision process of an activity and iii) suggested that one major criteria with which to scan the activity-space interface is that of the state of fit. This concept was further investigated by Nutt and Sears who

developed a comprehensive conceptual model which combines both the 'objective' and the 'subjective' approaches, as defined in their article on 'functional obsolescence'.(22)

The first approach centres around the physical, the financial, the environmental and the functional attributes of obsolescence, while the second involves the users' satisfaction in terms of tenancy, rent and aesthetic qualities of the building.(23) (24) (25) (26) (27)

The significance of the inquiry lies in pairing the extent of misfit to both the degree of tolerance of the activity system and the adaptability potential of the physical system. Further, the study also asserts that 'many changes to items of the built stock are irreversible or are at least very costly to reserve', whilst changes within the activity system could be 'reversible to a degree'.(28)(29) Correlatively, it therefore appears that the probability of changes in an activity system is higher than in a physical system.

Notwithstanding this inquiry, designers when confronted with the issue of change often sought their source of inspiration and guidance from their own experiences. Yet, a review of the available relevant literature suggests that in seeking the operationalisation of ideas dealing with the topic of change, it is essential to formulate the major causes of change in accordance with the nature of the organisation dealt with. This is, as Health argues, 'not to predict the changes that will affect the life of a given building, but the likelihood, rate and degree of such changes'. (30)

Implicitly, the occurrence of change is bound to be due to a number of factors. It is further postulated that 'it is the change in such factors that constitute the main causes of change in an individual activity demand over time'. (31) Attempts to describe the various causal factors suggest that these are closely connected to the nature of the activity. (32) Accordingly, the DfES paper entitled 'School for the Future', 'Which describes a philosophy of laboratory design intended to cope with the changing requirements of scientific and technological activity', taken together with some other studies in the subject showed four dominant forces shaping changes in university science teaching laboratories. These are first, the growth of student numbers in the fields of science and technology teaching, second change in technology, third change in the curricula and lastly change in the size of the activity. (33) (34) (35)

3.1. The Growth of Student Numbers.

It is a truism to claim from a metaphysical stand point that growth is a natural and intrinsic characteristic of the global evolutionary process that control 'things'. Though its significance in the field of architectural design is indisputable, the extent of its relevance is however questionable since extrapolating meanings surrounding the process of growth through an analogical presentation of matter could be misleading, as Cowan pointed out.(36) He (Cowan) further observed that i) unlike the mitotic mechanism that regulates tissue growth, 'buildings grow by accretion', appending external parts to an existing core and

ii) by contrast to the 'natural' occurrence of growth in living organism and some minerals, the growth phenomenon in the case of buildings eventuates as a result of 'human action'.(37)

Medawar argued that one prime variable contributing to the genesis of growth in human activities is the increase in the size of the social group dealt with. (38) The L.I.U's (now called the DfSE) investigation at the University of Surrey showed that the establishment of new premises subsequent to an increase in student population led to changes

within parts of the existing facilities. These changes were i) 'changes in use of existing laboratories' in terms of benching, storage, some services and part of the structure and ii) annexation and adaptation of space formerly assigned for other purpose. The study also observed that 'shunting' was the prevailing procedure whereby changes were brought about. (40) It therefore follows that, while it can be suggested that growth in the size of the social group could enhance the likelihood of changes in the fabric within which it is housed, it can equally be contented that growth in the group size generates the need for supplementary space. The provision of this extra space takes two forms; either the erection of new premises (growth by accretion) or the annexing and converting of spaces formerly used by another department. The former is referred to by both Cowan and Nicholson as 'real growth' or 'increase in floor space'. (41)

3.2. Change in Technology.

'It is widely and ritually repeated that a world of technology is a world of change'. (42) This implies that there exists an inherent impetus towards change in the use of technology. It is further argued that 'one of the most common characteristics of technology is that it brings about changes in physical nature'. (43)

A major factor that has enable new educational ideas to flourish are the use of technological monitoring devices e.g. closed circuit T.V, computers, and audio-visual materials. This is particularly true in science laboratories where the nature of scientific inquiry, which involves 'observing, measuring and building explanatory models to make sense of findings', has shown over the last two decades an increasing reliance on a myriad of mechanical devices and electronic equipment so as to cope with the development of new experimental techniques. (44) (45) The use of such tools has however led to a dilemma. Though technological hardware is considered vital to laboratory instruction, Weeks argued that it has contributed in developing a 'finite geometry' which could impede further developments of the organisation. (46)

The acuteness of the issue takes an extra dimension since change in technology seems to occur in an unknown direction and at an alarming rate. Studies surrounding the nature of the impetus for innovation in laboratory equipment stimulated some thoughts about the causes of such change. The first is that the technology in place might be surpassed by the emergence of a new alternative which could i) widen the spectrum of use, ii)

enhance the level of efficiency and iii) be cost effective in the long run. This can be exemplified by the L.I.U's hardware system (lab kit) which acknowledges current and predicated patterns of use. The second explanation centres around the fact that the occurrence of change in the performed activity (e.g. in its size and character), as a result of a new academic pattern within the institution, could i) limit the usefulness of some of the available facilities and ii) engender changes in some aspects of space such as the area and the height. (47) (48) (49)

The final consideration, as Duffy and Worthington pointed out, relates to the well of the organisation to incorporate novel ideas within its structures. (50)

To sum up, it could be suggested that if a dynamic science laboratory 'milieu' is to be provided, it seems best to formulate a positive prescription for its design. This could be based on planning for change and thus acknowledge that change in technology seems to be accompanied by a corresponding change in the laboratory physical environment. (51)(52)

3.3. Change in the Curricula.

Gone are the times when the 'Trivium' and the 'Quadrivium' concepts prevailed as the legitimate gates to higher education courses. The Gargantuan progress of science during the course of the current century has generated the proliferation of all kind of courses which 'range from the most pure to the most applied'.(53) Furthermore, the dividing line that once regulated the disciplines' boundaries has become less distinct as overlapping between them increases. Musgrove best described the above situation when wrote in the A.J in January 1965 he observed that:

Electronics has revolutionised techniques in every discipline to the extent that physics are to be found in almost every laboratory, no matter what named discipline it houses. (54)

These developments were reflected by changes in both the content and the internal structures of the disciplines. This in turn produced a growing tendency towards a multi-disciplinary use of science teaching laboratories.(55) (56) The operationalisation, however, of such a new educational concept gave rise to important requisites. Primarily, it has made the supply of a 'broader spectrum of facilities at any one teaching station' important since every discipline, though its requirements are substantially akin to some other ones, has nevertheless its own physical existence as well as theory, concepts, contents and methodologies.(57) (58)

Branton and Drake's study entitled 'Developing a Range of Adaptable Furniture and Services for Laboratories', which stems from an investigation carried out at the University of Surrey, observed that 'with multi-disciplinary use some changes took place from term to term' endorsing therefore the case for both flexibility and adaptability in use. The study noted two kinds of change: i) changes in the pattern of use e.g. changes in group work and ii) changes in some physical and environmental aspects of the shell e.g. adjustment to working areas, services,

equipment and furniture.(59) Additionally, the L.I.U paper No.9 argued that though the inclusion of a diversity of scientific tasks into a laboratory called for a much less stereotyped pattern of courses, it has contributed to the intricacy of estimating the number of students involved in a particular discipline.(60) It ensues therefore that change in the curricula appears to have subsequent repercussions upon the laboratory environment, thus suggesting that the design of science laboratories could be best upon its potential for flexibility and adaptability, in order to fit the eventuality of change

3.4. Change in the Activity Size.

A significant characteristic recognised to influence the activity-space relationship is connected with the activity size, to the extent that it is further claimed that occurrence of change in the activity's size could engender a reciprocal spatial variation.(61) Inquests surrounding this claim reckon that scanning the criteria by means of which to measure the size of an activity is a prime agent in seeking explanations of the extent of the congruence between the physical nature of the activity and its demand for space. (62) In this respect, criteria that set out the size of an activity include i) the total number of people involved in the institution and ii) the inherent 'texture' of the activity within an institution, for example the number of hours taught in laboratories or the number of beds tended in hospitals. (63)(64)

The applicability of these criteria is closely tied to the context within which the impact of change in an activity's size is to be explored since the variability of institutions characteristics implies a variability of units of measure. In some cases only the first criterion (i.e. number of people involved) is used to measure the relationship indicated above whilst in others a combination of both i) and ii) may be necessary. Exemplifying the former case in the study conducted by Duffy and Worthington in the field of office buildings. Their investigation released evidence that fluctuations in the number of personal were followed by similar fluctuations in the area housing them. The same affinity has been found by Cowan and Sears, whose inquiry about how an advertising agency accommodated change over a period of ten years showed that increase in the number of people involved resulted in a corresponding increase in the area that housed them. (65)

As far as laboratories are concerned, inquiries by the L.I.U group which employed both criteria i.e. that of the number of people and the of the intensity of use or the number of hours taught, demonstrated that increase in the size of an activity induced a parallel increase in the area used. (66)

Though it appears that there exists a pattern of association linking increase in the size of an activity to increase its spatial requirements can seldom be attributed to a single isolated factor. More often it is the combination of several factors which produces changes in the laboratory's activity. Thus a cognitive attempt which seeks the explanation and identification of potential causes of change in the context of laboratory design could best proceed

through a 'holistic' approach. Popper argued that the array of causes involved can not be regarded as the mere sum total of the factors dealt with nor it can be seen as the mere sum total of the merely individual relationships existing at any moment between those forces and the environment. (67) Change in the activity's size could be inherent to the incorporation of the concept of multi-disciplinary use, which in turn stems from the restructuring of the curricula. It could occur as a result of inter-alia such as the emergence of new technology or be consequent upon a growth in student numbers. Any of these cases could imply a need to erect new premises or expand existing ones to cope with the new size of the activity. (68)(69)

4. Design Strategies for Coping With Change.

Both research into and practical experience of laboratory design has brought to notice an interesting conflict between the life span of buildings and the effects of growth and change upon them.(70) Heath argued that taking into account the magnitude of change has at present become an established key to architectural design. (71) Moreover, to design, as Jones puts it, 'is no longer to increase the stability of the man-made world: it is to alter, for good or ill, things that determine the course of its development'. (72)

Accordingly, the resurgence of interest in the field of laboratory design, besides attending to the exigency to enhance the quality of health, safety and convenience requirements, highlighted the urgency to describe and predict the problems caused by change on buildings designers have come up with a diversity of ideas and proposals. These endeavours, noted in the L.I.U's study at the University of Surrey and in the Saint Michael's Academy's report, include improvisations in the use of laboratories, building extensions, conversions and minor changes to partitions, services and finishes. These however are not considered design strategies as such but rather as design aids to alleviate the effects of change on buildings. The most recognised and current design strategies, identified by Heath, are flexibility, the long-life loose-fit to which the attribute of low energy is now associated, and scrapping. Each of these three strategies has its own contextual use and each is discussed separately in the forgoing paragraphs.

4.1. Flexibility.

It has been argued throughout these lines that laboratory design is controlled by an array of design variables that are subject to change. These changes are often unpredictable, and in many cases result in a premature functional obsolescence of the premises. Although there is still controversy surrounding the inclusion of flexibility in laboratory design from its initial stages due to its expense, its incorporation, has become a preponderant key in planning for change.(73)(74)

Various approaches have been put forward by designers to provide flexibility in the laboratory environment. These, as pointed out by Clynes and Branton,

include i) laying out laboratories on a modular repetitive bay, ii) provision of services on a regular grid, iii) developing the structure of the building to take a wide range of alternative partition layouts, and iv) choosing or designing unit laboratory furniture so that it can be added to, subtracted or rearranged as required.(75) They further argued that while in items (i) and (ii) the stress is on flexibility.(76) The L.I.U paper number one argued that these 'tactics (as alluded to in the paper) can be successful in making a laboratory more amenable to change but in practice there are difficulties'.(77) For instance the flexibility of structure embodied in items (i), (ii) and (iii), which involves the concept of 'over-provision', is argued to be accompanied by an investment beyond the capital cost initially assigned to the building. The other difficulty, already discussed, is that of some environmental problems such as acoustics due to the limitations often associated with the use of movable partitions.

In the quest to bridge the shortcomings of these design procedures a number of designers developed new design strategies to achieve flexibility. There emerged various concepts, namely: the 'shell' in laboratories, the 'hierarchical organisation' or the 'support' concept in housing, the 'hard-soft' in hospitals and the 'shell-scenery' in offices buildings.(78)(79)(80)(81) Regardless of the institution within which these concepts are applied all centre around the distinction between those parts that are 'time-dependant' and those that are 'time-independent'. Arguably, there is no part of a building that is not time dependent; what is meant by the above phrases is the identification of those parts of the building that have been found to last longer than others, and are thus less subject to change. Despite the existence of a common core, concepts applicable to problems of one type of institution can not be applied to elucidate those in order institutions since, as AL-Nijaidi argued, the problem of change varies from one instance to another.(82)

The 'shell' concept is the basis of a key idea in laboratory design in which a hierarchical relationship is established between those parts of the building termed basic and regarded as long life ones (e.g. enclosure, structure and some services) and those parts identified as supplementary and regarded as short-life ones (e.g. partitions and furniture). The L.I.U report entitled 'An Approach to Laboratory Building' emphasised that the form and character of the shell stem from a number of criteria which are: i) overall area, ii) range of ceiling heights and floor loads, and iii) quantum of natural illumination needed. (83) The practicality of the concept developed by the L.I.U team to find out to what extent a shell can accommodate 'all the basic scientific disciplines' and 'how far a distinction must be made between the physical sciences with mainly dry services on the one hand, and the chemical and biological sciences with mainly wet services on the other' (84), has yet to be evaluated. However, it is significant to note that studies about the concept suggest that the principle of separation of a building system into physically independent sub-systems reduces the degree to which these elements act as a potential constraint to flexibility. (85)

4.2. The Long-Life Loose-Fit Concept.

The impetus that gave rise to the concept of long-life loose-fit sprang initially from studies carried out by Cowan and Nicholson in the field of hospitals and health care facilities.(86)(87) The concept refers to the relationship between certain physical attributes of the space and the activity it houses. This relationship, as argued by Gordon and Weeks, centres around the accommodation of change, and consists in bridging the gap between the long life of the structure and the short life of the activities they house. (88) Ideas for implementation of this concept pointed out two discernible approaches. One is 'over-provision' (T. Heath and the L.I.U team) or 'over-capacity' (C. Alexander), the other is neutrality (Al-Nijaidi) or 'indeterminate' (R. Oxman).

4.2.1. Over-Provision.

This first approach is based upon the idea of providing extra resources in the building than are initially required. This concept involves physical attributes (e.g. area and structure) as well as some aspects of services. The main argument for this procedure, as Al-Nijaidi points out, 'centres around the assumption that an extra provision would prove useful if the requirements of activities housed in rooms increase over time'.(89) The practicality of such a procedure remained however largely untested, for two main reasons. First, as argued by Lynch, Heath, L.I.U and Lawson, over-provision generally engenders high operating costs. (90)(91)(92)(93) Second, over-provision could only be justifiable if future requirements proved similar to the predicted requirements. Such a condition, Lynch argued, is seldom met and thus 'the whole exercise could prove unfounded'. (94)(95) Therefore it could be suggested that looseness of fit could prove unsatisfactory if over-provision is adopted as the ultimate procedure with which to counter the problems of change and uncertainty.

4.2.2. Neutrality.

The second approach to achieve the concept of long-life loose-fit stems from a general idea that the design should be 'as non-committal as possible', as Lawson advocates.(96) This idea goes further to refute the functionalist approach which failed to recognise the dynamism of change specific to the life of the building and the activity it houses. It made clearer the case for 'neutral' or 'indeterminate' buildings.(97) By opposition to a concept of a lasting design, neutrality developed as a design paradigm which attempted to incorporate both diversity and unpredictability as essential parameters of design in order to create buildings capable of responding open-ended to change and uncertainty.

The keys to achieving neutrality, as Al-Nijaidi argues, are uniformity and variety.(98) These two opposing concepts put to use to achieve neutrality involve either increasing or decreasing similarity between the various components of the building. Whilst uniformity embodies the notion of 'uniformity of room sizes', variety, on the

other hand, implies the reserve.(99) The argument for advocating a maximum of similarity revolves around two major axes. The first, as Weeks argued, is to establish the limits of required room sizes and subsequently to provide room sizes which can accommodate a number of 'duffle coat'.(100) Its application calls for a combination of an extensible pattern of communication with the provision of a set of room sizes which relate to a known range of activity sizes. The second is associated with the standardisation of some components of the hardware of the building, e.g. structural components and services.

The crux of variety, on the other hand, consists in 'the separation of the structural function from the function of partitioning' leaving therefore the opportunity to the users to subdivide the space according to their requirements. Although this procedure has been found to increase the potential for flexibility in the short term, Lynch observed that the exercise could prove vain in the long run. He further asserts that 'there must be many present variations which will never pay off when the unknown future change arrives; then the solution becomes a very wasteful one'.(101) Another difficulty, emphasised by Aylward, is that a fundamental condition to maintain the provision of variety is that activities and space must have long periods of misfit.(102) Hence while it is suggested that neutrality can be achieved by two distinct approaches, conceptually the reverse of each other (uniformity calls for maximising similarity whereas variety relate to minimising it), the first concept (uniformity) seems to have found more acceptance than the second (variety).

4.3. Scrapping.

The third response to uncertainty and change, and most controversial of all three design approaches, is scrapping, also called 'throw-away design'.(103) This concept refers generally to the readiness of a designed object '... to ease of demolition and re-use of demolished materials and equipment'.(104) Its main argument, as presented by Alward, is based on the assumption that if obsolescence is built in, then the idea of a temporary structure either in terms of its life span or its use span could prove beneficial.(105) The key to this design paradigm is the use of temporary structures or 'temporary hatted accommodation' as described by the L.I.U. The feasibility of such an approach is open to question. The L.I.U argued that it is liable to create low physical standards. (106) Schultz noted the problems implicit in using such an approach in the case of mega scale buildings such as universities, hospitals, and airports. He further claimed that it would be a real forfeit 'to build large scale structures with an economically justifiable short life span since heavy structural parts required for stability and safety are inevitably long-lasting', (107) thus rendering permanent those elements of the building which were initially considered temporary. One further criticism is that put forward by Lawson, who argued that 'this consumerist approach [scrapping] is not only wasteful of resources but also leads to short-lived goods of continually reduced

quality and thus the option of replacing outdated goods turns into a basic necessity'.**(108)**

Thus though scrapping has been suggested as a potential way to respond to change and uncertainty, the arguments of its advocates remained largely unsound due in the main to the serious limitations implicit in the essence of the concept.

CONCLUSION

As laboratory design has become more complex and as the rate of sociotechnic development accelerates 'the construction of predetermined unchangeable buildings become' more and more questionable.**(109)** The central idea of the article centres around the inclusion of a potential for change and uncertainty and subsequently to incorporate unpredictability and diversity as intrinsic parameters in the process of laboratory design. It has been argued that the diagnosis of the main instigators of change was an essential key in 'predicting, not the changes which will affect the life of a given building, but the likelihood, rate and degree of changes'. **(110)** accordingly, four major causes were identified. These include: i) growth of student numbers, ii) change in technology, iii) change in the curricula and iv) change in the activity size.

Three potential design approaches to mitigate the effect of change upon science laboratories were identified. These include: flexibility, long-life loose-fit and scrapping. All three have been found likely to induce high initial costs, and/or subsequent costs. While first two approaches found substantial ground for application the third concept remained largely unsound.

Accordingly, this article scanned succinctly these design concepts, manifested that ideas about flexibility and adaptability tended to suggest that while their main respective objectives centred around the quality of an object subject to change, highlighted uncertainty and unpredictability as important hallmarks of the situation dealt with. It also emerged that the impetus that gave rise to the incorporation of a potential for growth and change arose from the recognition that buildings in most rapid flux, such as universities, laboratories, hospitals and offices, grow, change and become obsolete rapidly.

Finally It has been argued throughout that the resurgence of interest about the subject of laboratory design, to improve health, safety and efficiency standards brought to light the complexity of having to design for the needs of an immediate use and yet having to meet responsively the occurrence of change and growth in the laboratory's activity.

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