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15th Triennial World Congress, Barcelona, Spain

CHANGING INSTITUTIONS THROUGH INTEGRATED CONSULTANT INTERVENTION: THE EXAMPLE OF THE UNIVERSITY SYSTEM

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Abstract: The question needs to be faced today how society can influence political developments and create political changes under conditions of ever increasing complexity of all social systems. This question leads to investigating the fundamental *changebility* of institutions. This paper deals with explaining the sluggish and superficial attitudes of institutions towards expected or required changes of their behaviour. Furthermore an intervention concept for institutional change is suggested. It is applied to processes of changing engineering education in the university, as an example of a fairly change-resistant social system. *Copyright © 2002 IFAC*

Keywords: Change management, engineering education, society

1 INTRODUCTION

The Universities of Technology world-wide are increasingly challenged by the demand to increase their commitment to industrial co-operation in research and education. Actually, about all engineering undergraduates would need to perform first industrial training activities during their period of studying in order to come up to the expectations of industry and enterprises today. Thus students may at least be required to perform some weeks of industrial practice training through placements under university supervision. In addition, the students may be offered a full semester (term) to be spent in industry on a proper professional engineering project.

Increasing numbers of students take advantage of such placements in industrial companies. About all countries offer today such progammes to students to expose themselves to industrial experiences, many of them going abroad, into the different European countries or in any country around the world.

In this paper, the present state of these programmes and their future perspectives are discussed against the background of societal changes which are being implemented world-wide through recent technology developments, and how universities are expected to respond in order to educate the *engineers of the future*.

2 INDUSTRY-ORIENTED GRADUATE RESEARCH PROJECTS

Beyond obligatory or optional *placements* as described in the Introduction, *industry-oriented research projects* are increasingly offered as an important part of the engineering curriculum and research activities. Many courses expect engineering graduate students to do different research and development projects in engineering. These projects may be performed in close co-operation with industrial enterprises. Many universities world-wide, however, have adopted such approaches to project work only very reluctantly. According to what is needed in industry and enterprises today, universities would specifically be expected to offer R&D projects to their engineering students which could be

- truly interdisciplinary,
- genuinely linked to the professional roles and tasks of engineers today,
- following as much as possible the individual aims and areas of interests of the students involved.

Only in this way it seems likely that the future engineers experience the reality of professional engineering R&D in industry today, already during their studies. The overall scope of these *truly professional* projects can be derived from an understanding of engineering as an activity or driving force with a *purpose within society*. This purpose would correspond to the challenges which technology today has to face.

In the following paragraph, some criteria are suggested to describe the framework of such professional projects. These criteria have been derived from recent discussions of international experts under the challenge of how to design and utilize new information and communication technology. The statements following here were drafted by one of the authors (D.B.) on behalf of the German *Association of Engineers* to be presented and discussed as the MEMORANDUM during the World Engineers' Convention, Hannover, Germany, June 19-21, 2000 (VDI, 2000). They refer to *Information and Communication Technology* as the main shaping forces in engineering of the future.

3. NEW TECHNOLOGIES IN THE VIRTUAL CENTURY

The Information and Communication Technologies today and tomorrow are exerting strong impact on technology development, industry and society world-wide. They may allow everybody

- to communicate with anybody anytime, anywhere, by sound and picture
- to gather, store and retrieve any data and information world-wide,
- to make any business transactions within seconds: shifting huge amounts of money about; selling, buying, moving goods world-wide; remote-controlling machines and people across and between continents, etc.

In the following paragraph, a few aspects of developing and utilizing these new technologies have been summarized with specific regard to the changes in the engineering profession. Several trends have been suggested followed by statements what engineers may be challenged to do in the near future. These statements were discussed and – in an extended version – agreed upon by the participants of the Congress on Information and Communication during the World Engineers' Convention 2000 in Hanover The statements mirror the tasks of universities in the near future and are illustrated here by some examples of research activities performed in several universities across Europe.

3.1 Global versus Regional Development: Law and Governance

The main trend today is towards globalisation: all communications and transactions take place within world-wide dimensions. These global networks have strong political impact on democracy, national and international security and the social welfare of all citizens.

There is a counter trend: Regionalisation. This provides an opportunity for participation, identification and local governance. There will still be places where people meet face to face.

Tasks of Engineers within Society and Politics

To contribute to more political control of technology-triggered developments through making more information available to all citizens

To discuss the political impact of global networks, the issues of democracy, national and international security

To give high priority to regional development in comparison to the global orientation in politics

Example of student research: Regional Network to involve SMEs in using the WWW for joint business

In one region of Germany, several SMEs have agreed to set up www-based links across the region in order to test the possibilities of offering services and winning customers, as a joint effort. Their www pages are developing towards a structure similar to a `stock exchange`. The development of cooperation is supported by teams of graduate students from the regional universities. These teams have designed specific computer interfaces and network structures for the optimum use of the internet by SME managers.

3.2 *Entrepreneurship on Different Scales: Economics and Business*

On the one hand, networking on a global ”macro” scale is leading to both strong economic co-operation and mutual dependencies of large enterprises and countries. Optimum use of information mobility and the world-wide available information influence survival and profit of such networked enterprises. The liability and responsibility of global enterprises, however, is no longer towards any specific country or people. There seems to be no control or governance possible through any single country. The economic-political impact of the global enterprises need increasingly to be taken into consideration.

On the other hand, small and medium-sized enterprises are increasingly becoming the backbone of economy and wealth of nations because they create the products, services and jobs needed for survival. In parallel, large enterprises increasingly understand their own employees as individual entrepreneurs on a ‘micro’ scale.

Tasks of Engineers within Society and Politics

To strongly increase international political co-operation in order to control the dangers of criminal business activities (e.g. enterprise pressures and blackmail)

To develop user-friendly, stable and secure technological networks for global business and transactions

To see themselves not only as the designers of new technologies and products but also as entrepreneurs on a ‘micro’ scale producing and selling them.

Example of student research: Linking enterprises world-wide in dress production from sheep to shop

The chain of dress production etc comprises: the sheep shearer in Australia – the wool combing and washing – dyeing – spinning – weaving – tailoring – selling etc.. This chain consists to a large extent of independent enterprises – mostly SMEs. Many of these enterprises are in competition with each other. Many of the work tasks which contribute to the final product are done repeatedly: e.g. quality control; others are contradictory: e.g. wool is being prepared to be perfectly white – but in the next enterprise along the chain, it is dyed black. Hence a group of such enterprises across the whole world, has set up a cooperative structure supported by new information technology. The aim is to minimize work and effort in treating the wool, and to shorten the process time of producing the dress according to fashion. The project was triggered and accompanied by a team of graduate students from computer science.

3.3 *Data Availability versus Data Security: Transportation and Processing of Data*

On the one hand, all information on the technological networks is available to everybody. Besides the personal desire for information and knowledge, these data are needed for all technical and organisational processes in business, production and for the protection of the environment. These data will grow in terms of both volume and complexity.

On the other hand, the misuse of the web and the breaking of data security are well known. Insufficient data reliability, trustworthiness and dependability are increasingly becoming a global problem.

Tasks of Engineers within Society and Politics

To design data processing systems in a way to take into account the need for security of personal data

To design technology for the contradicting challenges of data availability and data security

To develop new regulations for data access and data use in order to protect *individual freedom and personal data security*

Example of student research: Designing a firewall for co-operating enterprises.

About 10 years ago, former graduates of one university in Germany, started a new company to develop and market *firewalls* for complex open computer systems in industry and research to prevent virus attacks and unwanted access into the systems. Today this company is one of the world market leaders in such firewalls. Recently a group of young graduate students of the same university, developed the concept of a specific firewall for co-operating enterprises: the main feature is to allow *tunneling* between the enterprises which trust each other, while preventing un-authorized entrance from outside. The concept was successfully implemented in close exchange of experiences and know-how with the company mentioned.

3.4 *Reality versus Virtuality: Acting within the Global Net*

Within global nets we observe completely new ways of remote process control, and business transactions at a distance. Many experiences today are transmitted only through the technological networks. Thus they are frequently not accompanied by experiences of reality. There is sometimes the danger that we forget all about reality outside the technology systems.

Individual web users may become isolated from communicating with people in reality.

Tasks of Engineers within Society and Politics

To design automation and control technology networks (e.g. power stations, factories, aircraft etc.) so as to ensure that a competent human operator or system manager remains in charge of the system and is able to respond in an emergency

To take care of individual users of communication technology not to become isolated from real life and social interaction

Example of student research: Integrating reality and virtuality in chemical process control

Chemical process control comprises largely the performing of different tasks in a certain sequence. The processes to be controlled may be physical, chemical or biological. Today such plants are usually highly automated. The operating personnel may influence the individual processes mainly by varying certain flow rates of different process components.

In view of this complexity, today`s design of monitoring and control panels frequently make it difficult for the personnel to build up their own mental model of what is going on inside the automated system. Thus, the operational staff have a hard job in reacting to critical situations. Important indicators and characteristic factors are often not presented at all.

Thus many teams of graduate students have started out to develop new creative and innovative human-centered concepts and prototypes of Human-Machine Interfaces for such automated control systems which integrate many critical features improving and strengthening the roles of the human operator in the human-machine control loop. Through such new systems, the control room personnel are to create their own 'Expert System' incorporating all data and relations of both production process and products needed for optimum process control. These projects are performed in close co-operation with leading manufacturers of such control systems..

3.5 Education: Technology-based and Traditional Education

The growing availability of information and knowledge allows new educational use of the web. The speed of technological and societal changes forces people – also engineers - world-wide particularly to develop strong patterns of lifelong learning and continuously adapting to new conditions of life and work. Education will increasingly be based on the web and other related technologies (e.g. mobile and decentralised systems).

Hence, all education and learning should not only be based on technology and virtuality but also on traditional forms of education, on the reality of personal, social and professional life.

Tasks of Engineers within Society and Politics

To design teaching/learning technology so as to expect and encourage learners for their education not only to rely on the technology-based information but to confront themselves with reality outside the web and the media

To enable everybody across society to use and master information and communication technology leading towards new appreciation of the engineers’ roles and contributions within society.

Example of student research: Adult education through project co-operation

This project deals with regional development in Europe: in one of the important tourist regions in the (former East German socialist) State Saxonia. The project goal was to contribute to regional development through co-operative learning in enterprises towards *open networked business processes*: to develop a *joint family vacation concept.*

This concept aims at offering integrated holiday package options to families with children in the age group between 1 and 15 years. This aim characterises certain skills required to deal with the necessary changes within the region’s business structures. Thus it illustrates how *change processes* can be understood as *educational processes* across society. The project has been part of the strategy of the University of Technology (RWTH) Aachen, to place engineering graduates from university within industrial networks in order to offer technical and organisational consultancy and support.

First of all, the regional service providers need to learn how to cope with *economic competition*. Thus they need the ability to work with modern information and communication technology. Mainly through this technology, concepts and experiences of other tourism service providers are accessible. Communicating with these competitors enables *learning from experiences*. This skill has been important for the participants in the former East German region under the past socialist economy because of their lack of experiences with modern vacation offers. Thus the project team of engineering graduates developed different strategies in order to stimulate a process of *adult education through project co-operation.*

3.6 The Ethics of Multimedia Information and Internet-based Action

The calling-up and exchanging of information and pictures have proved their importance and necessity in personal life as well as in many fields of research, business, politics etc..

There is, however, the freedom of storing and sending all those pictures which symbolise the harmful or abusive side of human life (e.g. pornography, racism, violence and violent games etc.) It is unethical to transmit consciously and purposefully wrong and misleading information (i.e. misrepresentation of personal or group identity

Tasks of Engineers within Society and Politics

To design tracking systems for people who misuse the web (similar to the procedures for tracking hackers)

To develop new kinds of filters to check technology contents in a way to prevent the transportation of harmful and abusive pictures into and across the web

To discuss the ethics of information and pictures in view of the cultural pluralism of countries, their different traditions and value systems while avoiding to establish any one value system across the world.

Example of student research: Global industry networking and the issue of ethics

Increasingly, enterprises world-wide are being drawn into co-operation across national and cultural borders. Such co-operation, however, and its accompanying communications are continuously challenged by the differences of opinions which underly all communication. The global communication partners are forced to accept these differences or else it may even lead to break-down of all negotiations. Behind this challenge looms up the fundamental question of *ethical values* which no longer have any claim to universal validity beyond the borders of any one culture. Recently a group of graduate students from different universities in Europe and Asia have started to jointly discuss this fundamental question based on the concept of what today has been named Discourse Ethics. The students have visited industry and looked into international business communication processes in order to prove whether this concept is to be applied to economy-oriented co-operation networks across nations and cultures.

4. SYSTEMIC IDENTITY AND CHANGE PROCESSES

As discussed in the previous paragraphs, the qualification of future engineering graduates is expected to correspond to the industrial and societal demands. The socio-political relevance of engineering education comes from the increasing dependence on technical innovations for economic success, and for political and social stability. Specifically the very fast changes of all markets and changes in the industrial production processes mean more complex tasks for engineers and all other enterprise staff. These high requirements in engineering education have been for years transmitted from industry to the universities as those institutions which are responsible for such education.

But although all around the world, many responsible groups within the scientific community have been discussing necessary changes in contents and methods of engineering education, no satisfying results in the curricula improvements have so far been achieved - although the universities frequently maintain the opposite opinion. An endless number of committees from engineering, industry and unions, science, politics and economy have produced several lists of the necessary qualifications which engineering graduates need to master in order to be “fit for their jobs“, but during all that time only a few changes have been realised in the engineering courses at university. Not even political consensus has been found about which criteria we need to measure the quality of academic education. It seems as though universities are “blind“ not only against the actual needs of industry and society, but also against requirements related to the overall developments of society.

Following this conflict between change and continuity, one possible explanation for the behaviour of universities and engineering departments seems to be that the university and its departments are *social systems*. Each system shows a specific culture and identity which has developed out of their own mission and which is necessary to support the system against the environment. This demarcation is necessary for keeping the system alive, but it may make it also “blind“ against environmental demands.

This description about university as an *autopoietic system* explains to some extent how several elements make up the specific *identity* of each faculty (Rieck-mann/Weissengruber 1990): Such elements of the *faculty as a system* are, e.g.., the teachers, researchers, technicians, and the students (as the *members of the system)*; the faculty office *(*which may frequently represent some *economic system influences)*; the research departments *(*which may represent some *system innovation* through their research*)*; the different academic boards *(*which represent some aspects of *politics* within the university*)*; etc..

These elements work together as one faculty (*infrastructure*) and they develop their identity *against* other systems, e.g. other faculties, the national science policy and industrial demands (*system environment*)*.* Each faculty, also each university as a whole, exists and acts on the basis of its own specific historical development (the *history* of the institution*)*. It includes dealing with taboos, contradictions and conflicts (a certain *underworld* of the system) and dealing with more or less concrete perspectives and planning processes (in order to master the *future of the system*)*.*

The university represents such a system integrating the faculties and departments as traditionally grown sub-systems, each with a special identity that is based on a specific mission. This specific identity includes the system's own goals, strategies and rules, but also its influencing power and its leadership. Values and standards are transmitted by the typical attitudes of its actors (e.g. linguistic symbols, stories and myths, ideologies) but also through standardised attitudes (e.g. customs, rites).

Such s*ymbolic actions* are, especially in traditionally grown systems, a central element of their *internal culture* which is only applied by its actors because of a common understanding of the symbols. In a faculty this communication includes jokes, the formation of categories and self-made borders for thinking and acting. Also the power shows symbolistic interpretations.

5. THE INTERVENTION CONCEPT

The way to change such a system may be to integrate new elements into the system as if they were already *internal elements and components* of this system. If the system "feels", thus, disturbed by *internal* impulses ("autopoietic turning") it cannot easily reject them as conflicts from outside any longer. It then has to *react* on these change components in order to get back to its systemic harmony even if on a new level. This implantation ("*mirroring*") of change components into the system is the beginning of an *accepted* change process in the system's culture.

Such *mirroring* (in the meaning of "optical reflection") changes the self-perception of the actors within the system, it shows the system's own borders but also the "blind spots" in self-observation. This reflection obviously contributes to changes within the system (Maturana/Varela 1987).

Conflict management for system change requires *integrated consultant intervention*. It leads to the transformation of external demands into specific internal structures and helps to consolidate the change process.

Many examples of projects in Europe demonstrate the application of this *integrated consultant intervention*, e.g. changing engineering teaching and learning within traditional structures. They have been instigated and run by committed university staff members and students in the roles of these *integrated consultants*. They have taken up the challenges from *outside* the system in order to transform them into *internal* change stimuli. Nevertheless, universities need much more fundamental and broad change processes than those so far observed here.

6 CONCLUSION

The concept of *integrated consultant intervention* is needed in all kinds of systemic change. It concerns particularly all complex socio-technical systems (e.g. enterprises and administrations structured by both human processes, and information and automation technology). These systems are today under increasing pressure of continuous change. Through the strategy described here, the changing system experiences improved conflict consciousness and awareness, and thus it develops improved action competence towards its future.

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