Horizons in extension

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A. Brouwers, J. Graafmans

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Eindhoven University of Technology
Centre for Biomedical and Health
Care Technology
Postbox 513
5600 MB Eindhoven
The Netherlands

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A. Brouwers, J. Graafmans

Eindhoven University of Technology (EUT),
PO Box 513, 5600 MB Eindhoven, The Netherlands

INTRODUCTION

Over 10% of the research capacity of the Eindhoven University is directed towards the field of Biomedical and Health-Care Technology. Being a University of Technology this covers activities in which technical knowledge and skills are applied to problems in health-care and biology.

These activities are multidisciplinary in nature an therefore require cooperation between a variety of medical and technical scientists, medical clinicians, and Medical Technology (MT)-Industries.
Development, selection and management of projects in these fields must include an attention for ethical, economical, organizational, and political aspects as well.

A multidisciplinary project is directed towards a synergetical combination of several sources of knowledge, skills and information. Dealing with these combining activities over a time span of 15 years has proved to be a very demanding task. Furthermore it always requires good insight in the main characteristics of these contributing sources, and a judgement about their possibilities, as well as their impossibilities.

Structuring communication processes in multidisciplinary set ups, towards common goals, requires attention to the specific areas as well as the finite "horizons" of the participating experts and parties concerned. Extension processes have to be included beyond these "horizons", carefully designed and guided during the entire progress of such a multidisciplinary project.

The theoretical structure for Knowledge and Information Systems (KIS) of the Extension Science Department of the Wageningen University (Niels Röling et all 1989 [1]) provides a workable set up for the exchange of ideas and experiences on this topic. This paper focusses on the formulation of some generalities for extension in multidisciplinary activities and aims to project these on this theoretical framework, here referred to as N-KIS.

MARKET-IN

Generality 1
The effective management of knowledge and information is increasingly important for the continuity of organisations. However for many small organisations and for small industries in particular this is already becoming to difficult.

The line of thoughts in the paper has to start by stressing the importance of KIS-management as expressed in this statement. The knowledge transfer from university to (MT) industry is discussed briefly as a first case of extension activity. In doing so some marketing concepts are presented.

Considering the need of small industries, as stated above, a University of Technology has much to offer. The university can provide knowledge products for a market consisting of industrial companies.

In industry and trade it is well known that the continuity in the long run requires a strong "**market-in**" orientation, meaning that products must be developed that fit to real needs in the market and are based on careful research with respect to that.

This truism, however, is often neglected and instead a so called "**product-out**" orientation is governing the product development policy, i.e. an attitude with a too strong belief in the product and a too strong disregard for the real needs of the market.

Generality 2
University knowledge centres usually have a "product-out" orientation, and this has to change to a more "market-in" approach.

The N-KIS-theoretical structure of Wageningen stresses a strong need for more "**upstream**" influence instead of a too dominant focus on "**downstream**" transfer of "on-the-shelf" knowledge products. This aspect of the N-KIS framework can not be stressed enough. Generality 2 expresses the same aspect using other concepts.

Facilitating this upstream influence in the case University - (MT) Industry is initially taken care of by field research. Such a field exploration provides an example of market characterization for products of a knowledge centre. Since much of this approach may be projected on other fields, as well, the main findings are given in short terms [2].

The need for more knowledge in small industries (generality 1) was found to exist in the following topics, that are all generalities in themselves:
- Increasing knowledge contents of products.
- Increasing responsibilities for the products, which requires increasing care for product qualities.
- Increasing costs of product development.
- Faster obsolesence of production systems.
- Reducing life cycles of products, causing the necessity of a higher rate of product innovations.
- Reducing space for unsuccessful product innovations.
- More care for the environment in solutions for technological problems.

- Increasing need for effective management in a strategic perspective i.e. over longer periods and over a broad spectrum of product-market-technology combinations.

In this survey of (MT)-industry characteristics were found affecting the capabilities for extending the knowledge and information system:
- The finite capacity of the management and the large workload for mostly one, or a few persons, bearing the continuity of a small industry.
- A dominating "short-term-orientation" caused by the necessity to fulfill short term goals continuously.
- Specific knowledge, stored in a few persons, who also have a finite knowledge horizon, leading to weaknesses within the broadening spectrum of relevant knowledge on which the KIS of such a small industry should grow.
- Limited financial means.

A market for knowledge products has to be known very well for processes of knowledge transfer, even in much extended details as presented in this case. In order to enhance "upstream" effects substantially, a lot more has to be achieved. In most cases this is not realizable without compatible intermediaries.

INTERMEDIARIES

In the Wageningen theoretical frame work (N-KIS) much attention is given to the so called interfaces and linkage mechanisms. For example in most situations the "cultural distance" between research groups and target groups for extension is too big to bridge without such interfaces, i.e. intermediaries. In the theoretical structure of the N-KIS this is believed to be one of the most important items. Moreover it provides a practical approach to the design of knowledge and information systems.

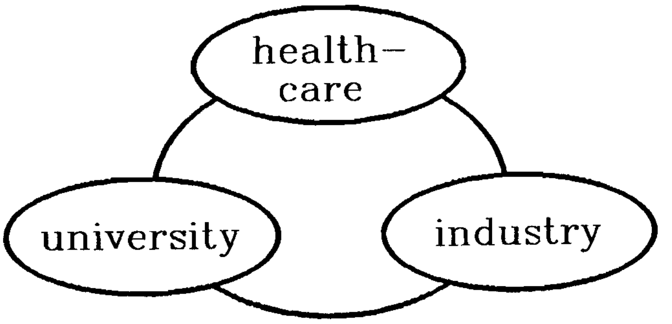

Fig. 1 *Good decision making regarding medical technology requires effective interactions between these domains*

In general more than two domains are involved in multidisciplinary projects. In the field of Medical Technology there always exist interactions between three general domains: Health-Care, Industry, University (see fig. 1). As pictured in the introduction the majority of such projects envelopes a great variety of expertise in these general domains. Each expert domain brings in a specific content of knowledge and information, has its own general aims, and its own finite horizons, causing particular needs for extension.

Such a multidisciplinary project usually cannot function without effective intermediaries. It mostly needs a powerful "**system integrator**". The management or coordination of such a project must facilitate mutual extension processes. A joint KIS has to be built up around the goals of the project and incentives of the parties involved should be projected on the general aim of the project. Real cooperation only works when all participants are gaining enough to make it worthwhile to invest all the required extra effort in multidisciplinary set ups.

An important finding in this respect is that this includes also the "**system integrator**" sometimes referred to as "**system moderator**". The fulfillment of the function of system integrator must be made beneficial, economical or otherwise.

Generality 3
In designing a KIS the intermediaries do form key elements (as pointed out in the theoretical framework of Wageningen); each KIS needs a powerful "system integrator", mostly being the intermediary (or one of them); the function of "system integrator" has to be rewarding in itself.

TIME HORIZONS

The life cycle of any distinguished medical technology is presented in fig. 2. Each phase in this life cycle requires its own different framework of experts, involved parties and intermediaries. Each phase has its own specific KIS, guiding standards and objectives and its specific necessities and constraints in the managerial care.

1.	Fundamental research	Genealogy
2.	Applied research	Conception
3.	Specific design	Antenatal stage
4.	First applications	
5.	Industrial innovations	Partus
6.	Clinical evaluation	
7.	Acceptance	
8.	Diffusion	Growth
9.	Saturation	Maturity
10.	Supplanting	Aging
11.	Obsolesence	Exitus

Fig. 2 Life cycle of a medical technology

The conceptual phases are mainily allocated in the environment of research centres. Gradually the centre of gravity is transferred to industry. Figure 3 presents a simplified scheme of the industrial process of product development.

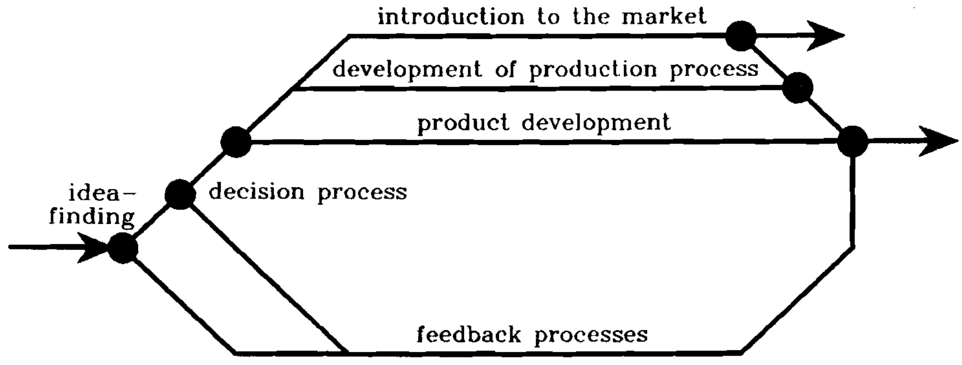

Fig. 3 Simplified scheme of a product innovation process

Within the scope of this manuscript a more detailed discussion on innovation processes in medical technology is not considered to be functional. Just the awareness of the mere existance of such an order of processes is sufficient for the understanding and introduction of the next statement.

Generality 4
In the continuum from fundamental research to a final product in the market many institutions are active (ref. N-KIS); they each create and transform knowledge and information in a specific way. In doing so they are not only seperated by differences in domains of expertise and daily praxis, but also by their finite time horizons regarding the total life cycle of the technology involved.

For a "system integrator" active in such a field this reality requires a broad span of control. Altogether it is an extremely difficult task to govern the downstream and upstream communication processes towards a successful innovation.

Activities, over several years, on relations between the university and specific target groups brought a practical and useful refinement in the picturing of KIS. As illustrated by figure 4, the Wageningen scheme may be shown along one axis. The different time horizons can be projected along the other. This serves to define in more detail the operational -, tactical -, and strategic processes. Each of this type of KIS processes has specific characteristics, - requires often typical actors, - provides specific needs for extension.

Generality 5
For communication processes on knowledge and information systems the following scheme can be of practical use: ***Fig. 4*:**

	operational tactical strategic
target groups **intermediaires** **research groups**	

Biomedical and Health Care Technology

a communication scheme: Industry-University

Eindhoven University of Technology

	operational	tactical	strategic
Industry in medical technology	- production problems asking for ad hoc solutions - optimization of production processes	- product innovation - marketing - project management - design of new production processes	- new technologies - market changes -strategy development or adjustment
Intermediaries	- university knowledge transfer center	- foundation for medical technology, Maastricht	- EUT center for biomedical and health care technology
Eindhoven University of Technology	- tracking expertise - ad hoc problem solving	- turn key innovation processes - project analyses - project management - post doc training	- strategic policies - medical technology assessment studies - expertise on trends in technology and health care -(inter)national networks

Gerontechnology

a communication scheme

Eindhoven University of Technology

	operational	tactical	strategic
elderly	- with ad hoc problems regarding primary necessaries of life	- searching for appropriate environments adaptable to increasing discomfort due to aging processes	- anticipating major changes in order to effect future independence
intermediaries	- health care professionals - social workers - consultants - media	- designers - local government	- project developers - national government
research disciplines	- general medicine - geriatrics	- ergonomics - technology - gerontology - gerontechnology	- assessment studies - epidemiology - politics

Two examples are given: one for the interaction (MT) Industry - University [2], a case already discussed before; one for the field of gerontechnology i.e. concerning the elderly in their aging process and their technical environment [3].
As a framework for communication between a variety of institutions a discussion usually is needed to bring such a scheme to life. These schemes are given without additional information as this is not considered relevant within the scope of this paper.

A notion of these different time horizons can be useful in certain extension processes. Another point considered to be important is the variety in standards over the institutions involved. It is an other way of picturing difficulties in extension work, - in KIS-design, - in multidisciplinary activities in general.

THE VARIETY OF STANDARDS

Generality 6
To a great extent a research process is enacted as a closed system [5].

Generally speaking a university researcher is mainly concentrated on a limited area of the total reality. Such a researcher applies specific tools of his own disciplines mostly on self chosen problems. A scientific career needs a considerable lot of time and dedication, so there is practically none left for much orientation outside his domain. In many aspects research groups can be considered as closed systems.

It is stated before (fig. 1) that medical technologies are being developed in interactions between the three main domains: Health-Care, Industry, University. The scheme of fig. 2 shows the type of research in the process of MT-product innovations. Between a new product in the market and the scientific research upon which it is based there is a certain interval. This interval or distance can be described as time required, manpower and provisions available. One can also distinguish between various forms of science. The distance between these forms of science and such a new product is variable. A common distinction is shown in figure 5.

It is the practical empirical science that is the most prone to a new product. Here one finds the realization of new products, methods, systems or processes. It is commonly described as applied research. Theoretical empirical science stands further away from a new product. Here research is oriented to the acquisition of more fundamental insight in the form of a theory or a given model of reality. The distance to a new product is even larger in the case of non-empirical science. Here analytical tools are developed. For example, mathematics is considered belonging to this branch of science.

MT research occurs in all these forms of science. A MT research project often has elements from all these manifestations of science. As a rule the accent in each case lies, however, in one particular manifestation or other. MT research is either strongly application-oriented or dominantly structured in the direction of basic insight.

In interpreting suggestions for new MT research projects or industrial products, it is important to consider the scientific starting point from which they have to come into realization. From the standpoint of application-oriented research a new product can be developed in a shorter period of time than would be possible by the transfer of

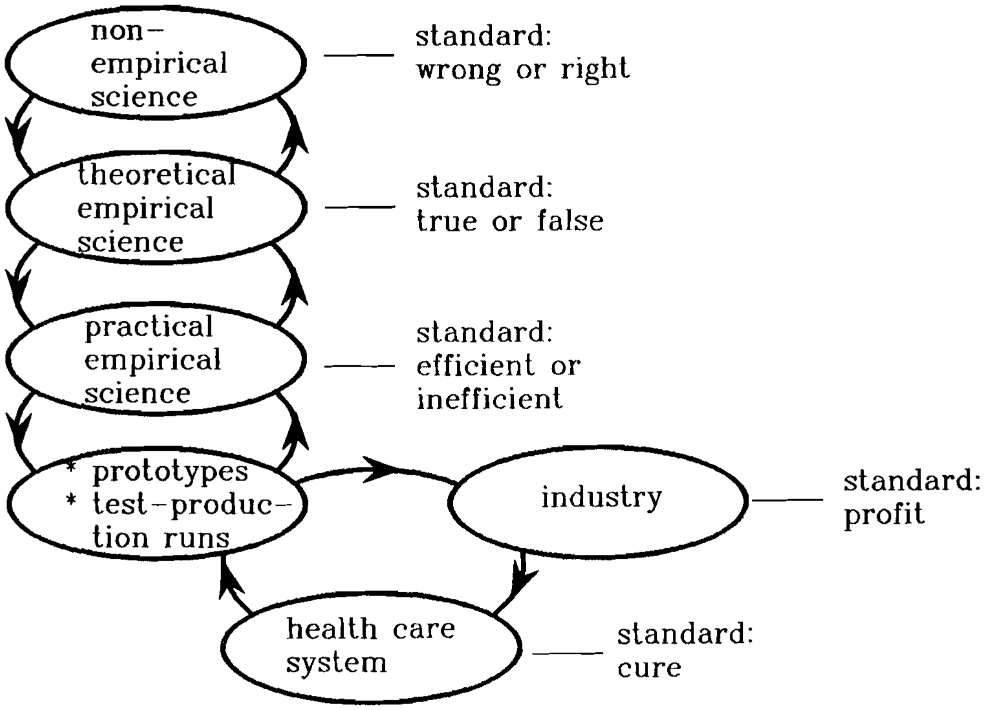

Fig. 5 Different domains and standards in MT product innovation processes

suggestions from more basic research. From successful basic research new insight can lead to more thoroughly considered specifications for a new product, with greater promise for successful development, but as a rule a great deal more has to be done before that is the case.

Generality 7

Each form of science has its specific standards guiding the research processes, - has its own closed system. The variety in these standards causes obstructions in processes of communication and cooperation.

This generality pictures one dimension of multidisciplinary research. Besides that each form of science contains many disciplines, providing a second dimension. Multi-disciplinary research as needed for MT-development often does form a complex structure along both these dimensions.

The MT-innovations are brought into realisation by the industry. The health-care system plays a role in this process. Industry and the health care system have different standards of their own; respectively **profit** and **cure.**

Generality 8

Multidisciplinary programmes need a strong "system integrator", and special attention for the need of mutual extension, including insights in the various guiding standards.

In the evolution of societies one development is very pregnant: **the growth in complexity.** Every modern society is above all characterized by an increasing amount of very complex problems. The Health-care systems form one of those complex problem areas in modern societies.

Science is making astonishing progress. One experiences a rapid increase in the number of specialities and increasing dynamics in all those fields of research. Our universities are producing excellent specialists in a variety of disciplines. However, our modern societies are lagging behind in dealing with the integration of the knowledge of the many experts needed for complex multidisciplinary problem areas. Too often important decisions do not lead to expected results because of the lack of adequate overall pictures of complex realities. The health-care systems are marked with experiences of this kind as well.

In dealing with these phenoma much can be gained by realizing c.q. increasing research and training facilities in the field of science extension.

SEGMENTATION

The N-KIS-framework of Wageningen is strongly based on systems theory. In applications of this theory much attention has to be paid to the definition or selection of the boundary of a system.

The N-KIS-structure reflects experience in these aspects of boundary determination and provides many useful references. A main guideline given is to draw the system boundary in such way that the total domain can be managed as a corporate entity, and as a system in which the synergy can be realized by attacking very practical problems.

Choosing the system boundary in this way makes it a subactivity integrated in the selection c.q. design process of the total system. The emphasis on controlability of the system and all recommendations in N-KIS dealing with that are definitely of great importance.

<u>Generality 10</u>
The system theory concepts of "observability" i.e. obtaining sufficient information to picture the processes in a system, and "controlability" i.e. having access to sufficient elements in the system to control its processes, seem to be both of practical use for the design and management of Knowledge and Information Systems (KIS).

The marketing concept of segmentation fits in this line of thought. Industry and trade pay much attention to analyses of product-market combinations. One typical product may fit into various segments of the market distinguished by specific characteristics, thereby requiring different approaches in selling the product.

Applying this concept to the EUT-case (MT)Industry-University, discussed before, causes a segmentation in the industries and in the knowledge products of the university. Consequently, knowledge transfer processes are being designed separately for each product-market segment. In this way another important constraint is taken care of as well, e.g. the need to realize such processes as small scale activities.

An other approach to segmentation is to be found in the case of gerontechnology.

GERONTECHNOLOGY

The EUT-case gerontechnology [3] mentioned before, provides another example of segmentation. The general object is the strong increase of the elderly in the western societies. In the Netherlands at present already 22% of the population is over 55 years of age. In the year 2030 this will amount 35% of the population [4]. Our societies have to prepare for these large demographic changes, however in many aspects societies are already lagging behind in taking suitable measures.

In all aspects concerning the elderly, gerontechnology looks dominantly to the technical environment. In terms of system theory this means an **aspect system.** The technical environment plays a role in virtually all activities of the elderly.

In doing so gerontechnology is looking for knowledge in many sciences concerning the aging processes. This has to be translated into specifications for technical products i.e. - to fill in many gaps in the knowledge of human factors with respect to aging processes and the consequences of these on independency and comfort.

Towards the industries of consumer goods a pushing power is being built up to design and produce appropriate products adaptable to the aging process. For industry and trade and many other institutions the elderly form a new market segment. This trend towards accomodating the elderly turns out to be important. It will come slowly into reality and it should be anticipated properly.

A segmentation is found by the distinction between operational, tactical and strategic processes as shown in the communication scheme of gerontechnology. A further segmentation has been found in activities dealing with: housing, transport, communication, recreation, nourishment, education, home health care. Each of these segments form special areas for optimization of the appropriate environment, - often with different groups of professionals and intermediaries.

Problems arise from the fact that the segmentations mentioned above, being adequate for improvements, do not match with the existing divisions of research disciplines, industrial branches, and governmental institutions.

<u>Generality 11</u>
It is obvious that in such a field as gerontechnology nothing will be achieved without a effective system integrator, growth in organizational coherence and a substantial extension programme.

INFORMATION TECHNOLOGY

The seminar in Wageningen has been directed to knowledge management & information technology. The latter part forms a last subject in this paper picturing EUT activities the field of biomedical and health-care technology within the frame work of the N-KIS. In the scope of this paper also this subject has to be limited to some general information and statements.

The development of information technology is considered to be important. At the EUT fundamental research in this area takes place in mathematical departments on programme structures and in the institute of perception research on underlying knowledge of the cognitive processes and in the field of informational ergonomics.
At the EUT several applied research groups are developing **expert systems (ES)** for a variety of domains. A few are directed to expertises in medicine. The department of medical electrical engineering developes **ES**, and instrumentalizes them in the design of MT-systems for complex tasks in health care.

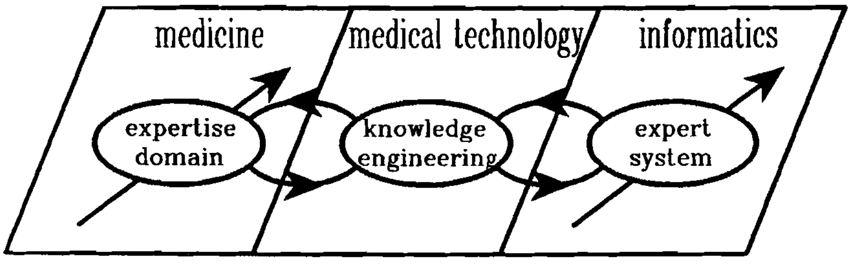

Fig. 6 Actors in the development of expert systems

The so called knowledge engineer (fig. 6) grows to be a new profesion as an intermediary between information technology and domains of expertise.

Generality 12
Training knowledge engineers must become a special task which needs a functional multidisciplinary anchoring in universities.

Concerning ES in the field of medicine the following policy is guiding the projects:
- Use existing ES-programmes, do not develop new ones of your own.
- Link up with a centre on information technology with experiences on ES, for standardization on hardware and software and for training.
- Choose the domains for ES carefully and as small and concrete as possible, - in which frequently descisions have to be taken, - with a certain complexity in the decision making processes, - on which recognized experts can be identified, - avoiding as much as possible domains with multiple experts.
- Do not expect miracles from ES on short notus.
- Do not neglect to become active in this field because the impact of artificial intelligence for sure shall have on the praxis of most disciplines in the future.

Generality 13
Domains of expertise in universities rarely fullfil the requirement for ES-development. Universities however can play an important role in developing ES for domains outside the university.

In many projects the introduction of information technology takes place without enough care for the organizational framework. In many situations organizational problems have to be solved in the first place before proper specifications of needs for information technologies can be derived. In general the state of the art of information technologies is far ahead of the capabilities of most organisations to apply them properly.

Generality 14
In most practical situations the organizational aspects are more important and require the initial attention; after that, and deducted from this, the introduction of information tools must be considered.

IN CONCLUSION

Generality 15
The theoretical structure for Knowledge and Information System of the Extension Science Department of Wageningen (Niels Röling et all 1989) provides a workable set up for exchange of ideas and experiences on this topic.

This paper tries to picture some long standing activities of the Eindhoven University of Technology containing tangent planes with this theoretical structure of Wageningen. Some related points are presented as generalities throughout this paper.

Dealing with so many subjects and aspects in one paper leaves only space for very general descriptions and brief statements. They may be seen as fruitful subjects for exchanges of ideas and for further elaboration.

Making journeys beyond horizons requires maps and travel guidelines. Wandering about the landscape of human knowledge also brings a need for navigation.
Each discipline should accomodate such travellers increasingly with appropriate science extension. In most disciplines, though, this activity gets insufficient attention and a low priority. The multidisciplinary problem areas in society require improvements of this situation.

Extension science can provide tools, techniques and training, useful to clearify the essentials within disciplinary horizons to one another, thus enabling joint adventures more easily.

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