Some Pedagogical Patterns from a System-Centred Approach

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Introduction

The Pattern-approach is very general, human-centred and holistic. Results and proofed problem/solution pairs from many different areas of science and working life have been identified. Although many patterns deal with problems in the software development domain, the pattern approach is much wider, particularly with regard to the impact of the work of Christopher Alexander.

Learning and understanding can be supported by or should even be based on a systemic comprehension of fundamental structures and processes in nature; a conscious comprehension based on biological, physiological and psychological foundations.

The quest for general principles and concepts applicable to different systems – biological, ecological, economic, social or technical – is the key motivation in "*cybernetics, the science of relationships, control, and organisation in all types of objects. Cybernetic concepts describe physicochemical, biological, and social phenomena with equal success.*" [Tur77]

Cybernetics is based above all on the concept of the *system*, a certain material object which consists of other objects which are called subsystems of the given system.

Patterns of this collection focus on identification of problem / solution pairs from different domains: biology/medicine, cognitive science and engineering from a system-centred – not to mention cybernetic – approach. Solutions to problems which occur in different types of systems are extracted by the author into a pattern form.

The general solution is followed by more concrete instances of the solutions applicable in the area of learning and teaching. The patterns of this collection follow the Alexandrian form, which itself is the subject matter in a pattern of this collection: ARC OF INTENTION.

Overview

Pattern	Key question
SYSTEM AWARENESS	How to acquire knowledge about entities and material or conceptual elements which are in complex relationships with mutual dependence on others?
DIVISION OF LABOUR	How can the fulfilment of more extensive and more specific tasks be guaranteed, when systems become larger and more complex?
NESTEDNESS	How can we organise extensive systems so that co-ordination, control and information flow can be performed efficiently?
FEEDBACK LOOP	How can systems be organised so that they can more efficiently influence their environment towards an achieved state?
AWARENESS BY DIFFERENCE	How can possible important information be recognized more efficiently?
CONCURRENT PERCEPTION	How to pursue your own goals without experiencing disadvantages caused by the surrounding environment?
NETWORK STIMULI	How can information processing be sufficient to react immediately, despite electrical signal forwarding in the neural net is relatively slow?
TANGIBLE PROCESS AND RESULT	How can intellectual work be additionally motivated considering the fact that our cognitive system was originally designed for processes and results of a physical nature?
SMOOTH INCREASE OF KNOWLEDGE	How can knowledge be acquired more efficiently?
ARC OF INTENTION	How to transfer specific content to a real-time audience or one separated in time or space efficiently?

SYSTEM AWARENESS

Figure 1: M. C. Escher:
Hand With Reflecting Sphere

Modelling of the real or conceptual world in order to acquire of knowledge of it.

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Almost nothing exists on its own without a surrounding environment. There are relationships between almost everything: entities, material or immaterial elements as parts of models of reality. Focusing on an isolated element inhibits or prevents acquiring knowledge about it and the context of the element. Without considering the variant interdependencies and relationships between elements, an understanding of a single element is difficult and insufficient. Taking all interdependencies into account may result in an overwhelming amount of facts to be considered. An unlimited scope also inhibits or prevents acquiring knowledge.

Acquisition of knowledge about entities and material or conceptual elements is difficult if they are in complex relationships with mutual dependence on each others.

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Focus on an amount of highly interdependent elements which is easy to grasp and draw a clear dividing line between these considered elements and the surrounding.

The decision which elements have to be considered depends on interdependencies and chosen priorities, too. Applicability and usefulness will assert the decision prior made. Due to appropriateness considerations may change over time.

This is the fundamental system concept which allows us to acquire and expand knowledge by modelling reality. Identification and modelling of systems is the basis of thinking and reasoning. Thinking and learning is highly dependent on SYSTEM AWARENESS[1].

1 Pattern names in this collection are in CAPITAL LETTERS

You as an individual should be aware that acquiring and expanding knowledge is based on the process of identifying objects together with their relationships within system boundaries – apparently or in fact drawn by nature or artificially set by yourself.

You should be aware of the fact that:

- Human capabilities of identification and internal representation of complex and multilateral systems are limited.
- Modelling can only focus on a limited amount of objects and relationships. More important general facts are considered while details have to be omitted.
- The price for a more complete model of reality is a loss of easy and efficient handling.
- Humans are part of ecological, social and economic systems. SYSTEM AWARENESS supports or enables efficient, reasonable and responsible planning and acting.

You as a teacher should be aware of the systems influencing your teaching activities: identify and consider relationships, mutual influences and changes over time among the objects of your system: students in your courses, schools, universities.

As a teacher you should encourage your students to establish SYSTEM AWARENESS by teaching system-oriented and systemic thinking.

For any higher living form perception is fundamental. Humans and higher animals learn the meaning of recognised things and new concepts by building associations with knowledge acquired earlier; this is the process from signal to information. Learning depends on the richness of associations.

Information representation and retrieval is more efficient if information units are organised into chunks, semantic maps and hierarchies. Perception and association comprise selection and perception of elements and their relations and then modelling the selected focus of reality. In other words: the concept of "system" seems to be intrinsic to thinking. The term "system" itself is hard to define. Some definitions from the Principia Cybernetica Web (http://pespmc1.vub.ac.be/ASC/SYSTEM.html):

> *SYSTEM 1) a set of variables selected by an observer. 2) Usually three distinctions are made: 1. An observed object. 2. A perception of an observed object. This will be different for different observers. 3. A model or representation of a perceived object. A single observer can construct more than one model or representation of a single object.*
>
> *Any portion of the material universe which we choose to separate in thought from the rest of the universe for the purpose of considering and discussing the various changes which may occur within it under various conditions is called a system*

Models and representations of perceived objects depend on selections made by individual observers. The forms of observation change, as well as the observed objects and their relationships. Thinking in systems or systemic thinking is intrinsic to cognitive processes. SYSTEM AWARENESS provides an efficient way to deal with the complexity of the environment and immaterial world, too.

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The concept of systems is so fundamental that examples for SYSTEM AWARENESS may occur in a wide range and in great number. Some examples come from the area of learning.

Human information processing is very complex. Information transfer and processing depends on physical abilities, as well as on psychological ones. If you want to communicate or interact with a person who is hungry or threatened by a (real or virtual) danger, you will not have much success. Considering Maslow`s "Hierarchy of Needs" / "Pyramid of Needs"(figure 2) such an attempt fails because lower needs – physiological and safety needs - are not met.

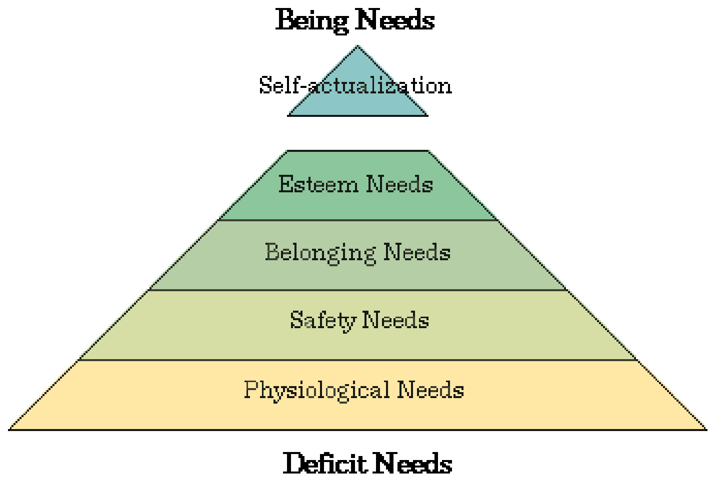

Figure 2: Maslow's Hierarchy of Needs (from [Boe03])

Human information processing is not machine-like: emotions and individual circumstances influence the way information is transferred, processed and learned. Without SYSTEM AWARENESS you might try as hard as you want to convince somebody if they are not emotionally willing to interact with you.

Division of Labour

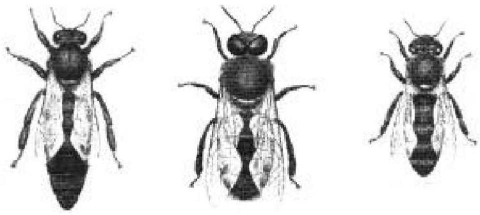

Figure 3: Queen, Drone, Worker

Organisation of emerging systems in order to accomplish more complex tasks.

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If the amount of work in a system increases, a single individual cannot accomplish it.

If systems become larger and more complex, tasks of different kind can occur. Skills of an individual are then no longer sufficient to fulfil the pending tasks.

Large and complex systems need more extensive and more specific tasks to be fulfilled which can not be achieved by just increasing the number of identical parts.

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Organise work among specialised units which are better adapted to an increasing number of, and more specific, tasks.

Co-operation of specialised parts needs coordination. Groups of highly interdependent parts form sub-systems. The organisation and cooperation of such sub-systems is more flexible if they are loosely coupled. Both principles are referred to as "high cohesion – loose coupling".

Extend of the number of systems elements results in increasing effort of coordination and control for goal-oriented accomplishment. Nested partial self controlling sub-systems are a common solution.

In evolution the fundamental principle of Division of Labour occurred very early in connection with Nestedness. In nature systems evolved as hierarchically organised units which are specialised for specific tasks. Such systems have advantages over systems of unspecified mono-morph structures. Work-sharing systems are more efficient and better adapted to increasing environmental challenges. But changing environmental conditions demand flexible adaptation of the division. This process of dividing work is hard but often essential for the systems surviving.

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Examples of systems where Division of Labour is applied:

- *Biological systems: Receptor-Control-Systems, Symbiosis*
- *Technical systems: Industrial production*
- *Software Engineering: Master-Slave-Pattern, Construction of Algorithm following the principle of "Divide and Conquer"*

NESTEDNESS

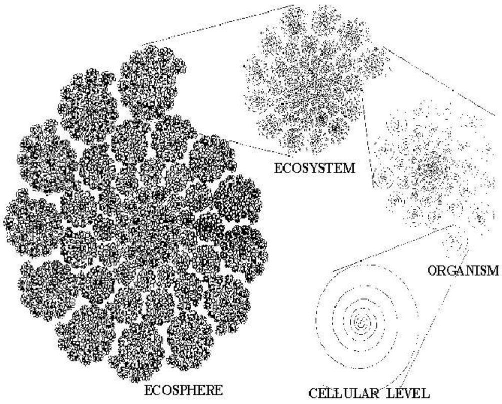

Figure 4: levels nestedness in living systems

Organisation and control of complex systems.

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Due to DIVISION OF LABOUR systems consisting of a larger number of elements are able to perform larger or more complex tasks. Work load can be shared among similar elements, specific tasks are accomplished by specialised elements.

An implication of increasing system size is an increasing effort of coordination, control and communication in the system. Information processing and data flow rise.

Applying larger numbers of specialised elements is accompanied by costly development and maintenance due to their larger variety.

Human information perception, processing and storage is limited in its understanding and representation of extensive systems.

Extensive systems need coordination and control based on information flow but effort to carry them out increases dramatical with the number of involved parts.

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Group highly interrelated elements as sub-systems within a nesting system: the principle of NESTEDNESS. Systems consist of elements which can be systems themselves – i.e. subsystems, working together for the overall objective of the whole system.

To deal with coordination of increasing numbers of elements, organise them into layers and hierarchies. Hierarchical organisation facilitates or allows control of complex systems. Subsystems are partially-ordered structures grouped by class or rank. Criteria for grouping i.e. partitioning are e.g. functional or information cohesion, control and deployment.

Well known partitioning principles are: Low coupling/high cohesion and information hiding.

Nestedness

You as an individual should apply Nestedness to organise and control complex systems. Nestedness is a key principle in engineering and organisational sciences.

You as a teacher should apply Nestedness to organise courses, faculties and other educational units; enable students to gain experience of Nestedness by building up and organising larger systems by themselves. Working on more complex projects in a team supports the experience of Nestedness.

Ordering elements in levels according to an ordering principle leads to a hierarchical structure. A common ordering principle is transmission of information from bottom to top and vice versa. Abstraction of information - information content / entropy - increases as you ascend the levels of the pyramid. The size of systems which can be understood and controlled by information processing and controlling entities of limited capabilities can be greatly enhanced.

Seen from an evolutionary angle, hierarchical systems arise from arranging smaller numbers of interconnected elements as coherent subsystems exchanging information with an element of the next level above.

Flexibility, adaptability and creativity of large systems can be improved by admitting multiple parentage from the above level – this leads to a heterarchical structure – or even allowing multiple parentage across levels. Weakening strictness of the hierarchical structure increases the control effort and makes understanding more difficult.

> *"... any complex system which has arisen by the method of trial and error in the process of evolution should have a hierarchical organization. In fact, nature — unable to sort through all conceivable combinations of a large number of elements — selects combinations from a few elements. When it finds a useful combination, nature reproduces it and uses it (the whole of it) as an element to be tentatively connected with a small number of other similar elements. This is how the hierarchy arises. ... In fact, any complex system, whether it has arisen naturally or been created by human beings, can be considered organized only if it is based on some kind of hierarchy or interweaving of several hierarchies. At least we do not yet know any organized systems that are arranged differently" [Tur77]*

NESTEDNESS allows co-operation and co-ordination within a sub-systems so less system wide information flow is necessary and reaction time is shorter. Local reaction abilities increase robustness. Due to local adaptability nested systems are more flexible.

NESTEDNESS supports managing of complex systems: cooperation of functional areas enables the network to accomplish more complex tasks than non-linear mapping and dynamic evolution can do.
Complex control systems, such as organisms or organisations, have an overall goal. Control on the higher level is manageable because local control tasks are performed in the sub-systems, which may work together in networks to accomplish tasks of their abilities and responsibilities.

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NESTEDNESS is found in most larger biological, ecological, economic or technical systems as some examples illustrate:

- *Biological example: The Brain*

  The brain is a system of 10^{10} neurons and seems to have a hierarchical architecture. The top hierarchy is the division of cerebellum, thalamus, hypothalamus, cortex, hippocampus, and cerebrum.

  The cerebrum is also divided into hemispheres: left hemisphere is responsible for logical reasoning and the right one is good at conception association. The cortex of the brain is also divided into many functional areas, such as the visual and the olfactory area.

- *Cognitive science example:*

  Rasmussen's model of skilled behaviour consists of three levels:

Level	Features
Knowledge Based (KB)	Conscious, effort loaded attempts to solve new problems, slow velocity
Rule Based (RB)	Pattern-matching of prepared rules / solutions to problems which are trained for, intermediate velocity
Skill Based (SB)	Automatic control of routine tasks, very fast

In case of new situations the whole so-called ladder (figure 5) has to be climbed up and down. With more experience lower levels are sufficient to react: the flow follows a shortcut.

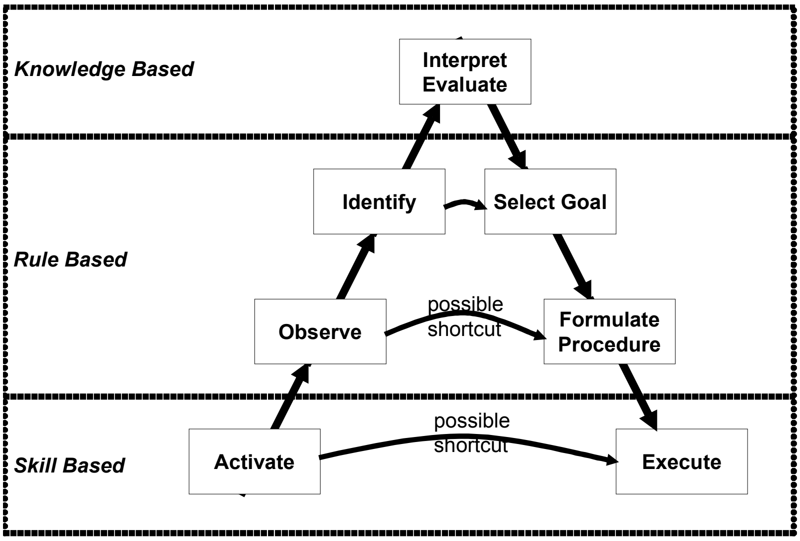

Figure 5: Rasmussen's model of skilled behaviour (after [Ras83])

- *Organisational examples*

  Hierarchical structures are most common in political or economic organisations: government, army, companies.

- *Technical examples*

  The technical revolution accompanied hierarchical organisation of production and hierarchical composition of products out of components produced and assembled in processes based on the division of labour.

  Control systems of larger production plants are hierarchically structured: from sensors, embedded controllers and actors as parts of machines up to production planning systems.

  Key aspects of software engineering are modularization, abstraction and reuse in well-defined processes - this way software development became an engineering discipline.

FEEDBACK LOOP

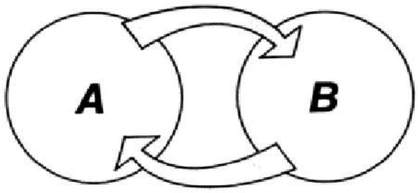

Figure 6: Feedback loop (from [Tur77])

Biological or technical systems with goal driven subsystems / parts.

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Natural and technical systems want to influence their environment in such a way that the environment changes to an achieved state. But there is no proof that by such an action a certain achieved state will be reached.

If the environment has changed previous successful actions may now fail. Dynamic systems tent to non-linear effects and unpredictable changes. Non-intentional inputs may prevent intentional input from succeeding. In changing environments reaction schemes have to adaptable. Adaptation needs information whether a chosen reaction results in intended new situation or not.

If system parts react to a given situation in a fixed way they will fail in dynamically changing environments.

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Act stepwise on the environment considering the resulting situation by feeding back the output and comparing it with the intention in a closed loop.

Feedback loop control systems are characterised by four elements:

1. A **sensor** to feed back the captured system state to the comparator.
2. A **goal representation** that specifies the intended situation by a set of values.
3. A **comparator** that compares the actual sensed situation by means of measured values from the sensor, with the desired situation represented in in a comparable value set. The deviation – error signal in technical systems - determines which way a correction needs to be made.
4. An **actuator** which performs an action on the environment determined by the deviation.

Figure 7 shows these four elements as parts of an active element that performs actions on its environment: other elements of the system. Behaviour of feedback loop control is characterised by the frequency of acting and capturing the results and by the ratio of action to the error.

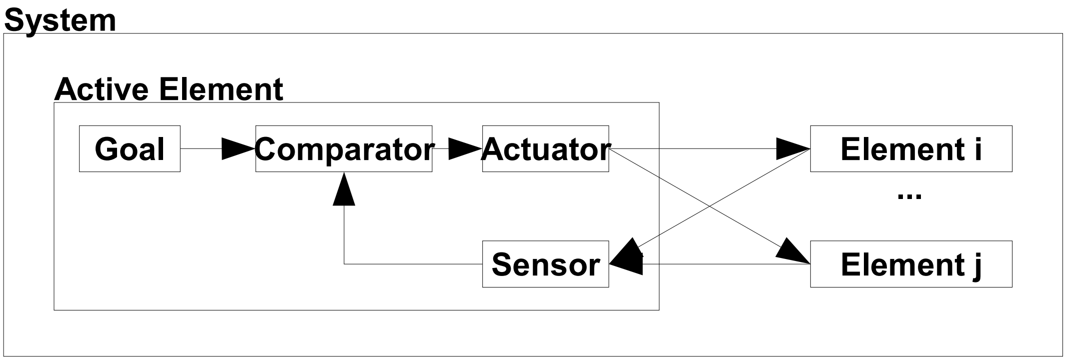

Figure 7: Feedback Loop Control System

Benefits of feedback are the ability to compensate disturbance and non-linearity of the other elements. Stepwise correction promises to avoid overreactions. The ongoing process of acting in respect to the results of the previous action allows active elements to pursue their goals under conditions of changing and unpredictable environments.

Feedback is no silver bullet: if small errors cause strong actions, this results in an over-control, or overshoot. Another stability problem is oscillation, that is, a sustained cyclic response without any input. This effect generally renders the system useless or even destructive.

You as a teacher have certain teaching goals: primarily, efficient and lasting transfer of knowledge. Be aware, that you as an active element has to establish sensation to get useful feedback from you audience – reaching from verbal responses to non-verbal communication. Furthermore, you are an "environmental element" of the learners from their perspective as active elements.

After undertaking actions on your learners as the main parts of the teaching environment a certain situation (state of knowledge of the learners, feeling of the group, ...) is reached. Now you have to analyse the level of achievement of the goal and perhaps have to change the steps on the way toward the complete goal. Iterations result in improved contents which gives feedback as well. Input for the next iteration is both improvement of content and feedback from your environment as well. Consider SYSTEM AWARENESS.

The repetition rate is very important. If test results at the end of a semester are the only input for a one shot comparison (one single loop), it might be to late for corrections or changes!

[FV01] describe a Feedback pattern for teaching in courses and seminars.

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FEEDBACK LOOP is widely common in most biological, social, ecological, economic or technical systems as some examples illustrate:

- *Biological examples:Pupillary Reflex*

  Eyes of higher animals and humans have an effective system to control the amount of light that is let into the eye. The opening of the pupil is adjusted depending on the measured light intensity. Experiments have been made by changing the light intensity and measuring the pupil opening. Results show that the opening mechanism is a very effective feedback system.

- *Norman's model of information processing and acting*

  Several models of human interaction with the world were developed in cognitive science. Many of these models - like that from Norman (fig.8) consist of a loop in which the interpreted perception of the world is compared with the actual goal. On the basis of the achievement of the goal new actions are planned and performed.

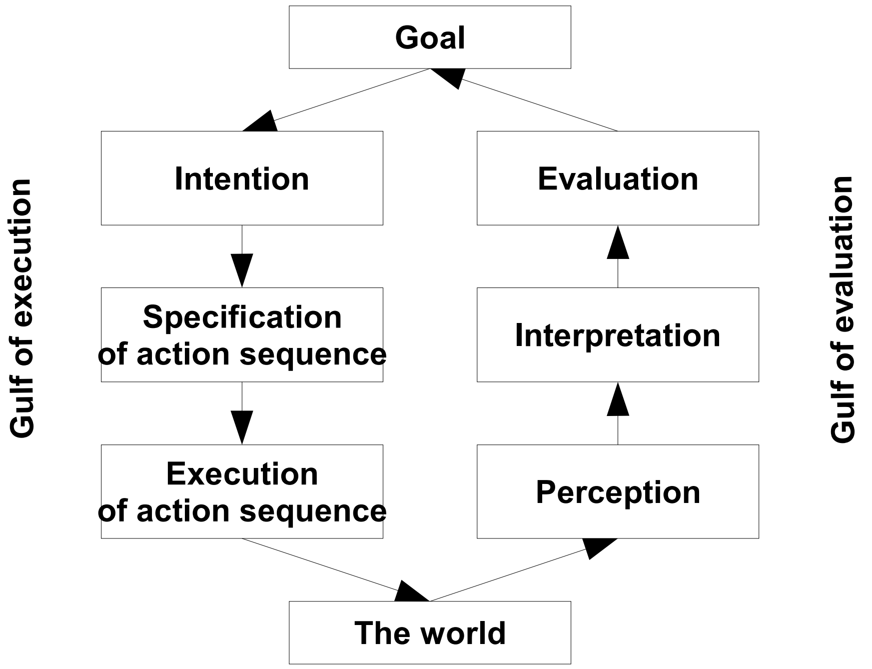

Figure 8: Norman's seven stages of action (after [Nor86])

- *Human Posture*

  The human body has many feedback systems. They allow us to stand upright, to walk, jump and balance on ropes. They also adjust the sensitivity of our eyes and ears, enabling us to see and hear over a wide range of intensity levels. They maintain a constant body temperature and a delicate balance of chemical substances in our body.

- *Social example*

  Education and training is widely based on the Feedback Loop. Learners measure the feedback /results of their behaviour and actions given by their environment: parents, relatives, friends, teachers and other social or economic (sub-)systems.

- Engineering

  A key technical development for industrialisation was the construction of closed-loop control systems and the emergence of control theory in mechanical and electrical engineering. Figure 9 shows the basis structure of feedback loops.

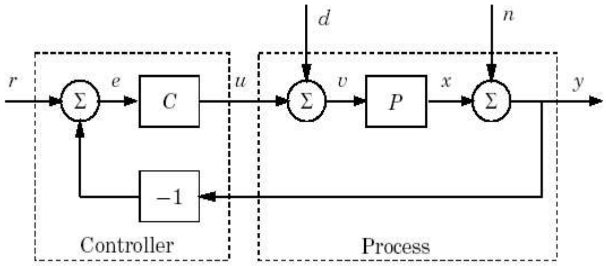

Figure 9: structure of feedback loops

- *SW-Engineering*

  When software engineering progressed it was discovered that software development processes based on an open loop failed or were inefficient. Closed loop examples with incrementally evolving products are the spiral models, evolutionary models and extreme programming.

- *Ecological examples*

  Biological systems in smaller as well as larger ecological systems are driven by the struggle for survival. Nearly each single action chosen by an entity has a resulting effect on it. The effect is either actively assessed by the actor according to the level the goal is achieved or passively in that the action has a regulating impact on the acting entity.

> *The organisms we see today are deeply marked by the selective action of two thousand million years' attrition. Any form in any way defective in its power of survival has been eliminated; and today the features of almost every form bear the marks of being adapted to ensure survival rather than any other possible outcome. Eyes, roots, cilia, shells and claws are so fashioned as to maximise the chance of survival. And when we study the brain we are again studying a means to survival.*
> [Ash57]

FOCUS ON DIFFERENCE

Figure 10: M. C. Escher:
Sky and Water I

Efficient perception of relevant information in larger and changing environments.

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Perception of unchanging environmental states decreases with time. Continuing perception of unchanging environmental states ties up resources of the perception apparatus unnecessarily and therefore contradicts the fundamental principle of efficiency.

In larger and changing systems focusing on relevant information is costly or impossible by perceiving the state of all elements.

* * *

Focus on differences to gain information in changing environments under reasonable effort and high probability relevance of it.

In evolution it turned out that essential information is attained by perception of change. Therefore the perception apparatus of most life forms is suitable for perception of change as the difference between a present state and a previous one.

You as a teacher, speaker or lecturer be aware that attention follows contrasts.

To emphasise important information you can use contrast in

- volume or register of your voice,
- usage of colours on slides
- choice of media, etc.

You as a teacher can let your students discover important content by making themselves experience differences Perception of difference is efficient and resource saving: work load of receptors and the cognitive system is minimised. Depending on the available receptors, the perceptible state of the environment includes values of different attributes like colour, temperature, volume, etc.

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CONCURRENT PERCEPTION

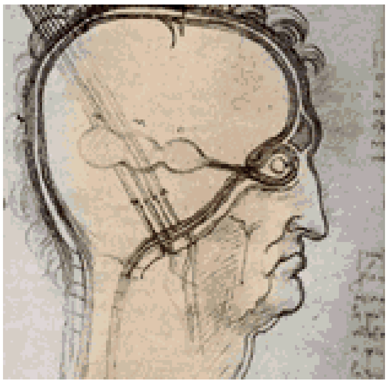

Figure 11: Da Vinci's illustration of visual perception

Natural entities interacting with their environment.

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Pursuing a goal is most efficient if all necessary available resources are used to reach it. In nature most entities pursuing their goals have to do it in a given environment with – as a rule – competitive or opposing goals. Paying no attention to other entities may result in a disadvantage or even worse.

In dynamic systems active elements focusing on their own goals without recognizing actual changes of their surrounding environment will most probably fail.

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Perceive the subjects of your acting and the changing environment concurrently.

In evolution those life forms prevailed have the ability of concurrent perception. Higher animals and humans use multi channels to take signals from their environment. Perception, discrimination, evaluation and decision making run in parallel. In the case of essential tasks – e.g. for survival – such activities are not under conscious control. In the early stages of evolution nature already created life forms with the ability to have concurrent perception and processing of signals. At least perception and processing in order to discriminate one of the two most abstract and essential concepts – prey or adversary / enemy – were carried out in parallel.

You as a teacher should bear in mind that humans cannot switch off the information channels that are not in charge of the information you want transferred. Use them, if possible, for multi channel reinforcement.

In the case of a mainly visual information presentation and desired perception you should avoid or remove other signals – sound, smell, light effects, etc. - if they do not contribute to the desired results or you should use them selective to support the desired learning result.

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Concurrent Perception

Learning is most effective if several senses are involved in the process of perception.

Franz Decker proposes an increasing remembering ratio if more input channels are involved: we remember

- *20% of what we only hear,*
- *30% of what we only see,*
- *50% of what we hear and see*
- *70% of what we hear and see and then actively discuss*
- *90% if we can actively that do, what we have seen and heard and discussed upon.*

Due to modern medical technology the effect of Concurrent Perception can be visualised by measuring the blood activity in the brain (cfg. [LIS83]). Figure 12 shows pictures of the blood flow activity in the left side of the brain in two situations: Reading silently and reading aloud.

On the left side the activation pattern is shown when a person is reading silently. Four areas are stimulated: the field of visual associations, the frontal eye field, the motor field and the lingual centre.

When reading aloud (right figure) two further areas are activated: the mouth field and the aural centre. The average activation level is higher on the right side.

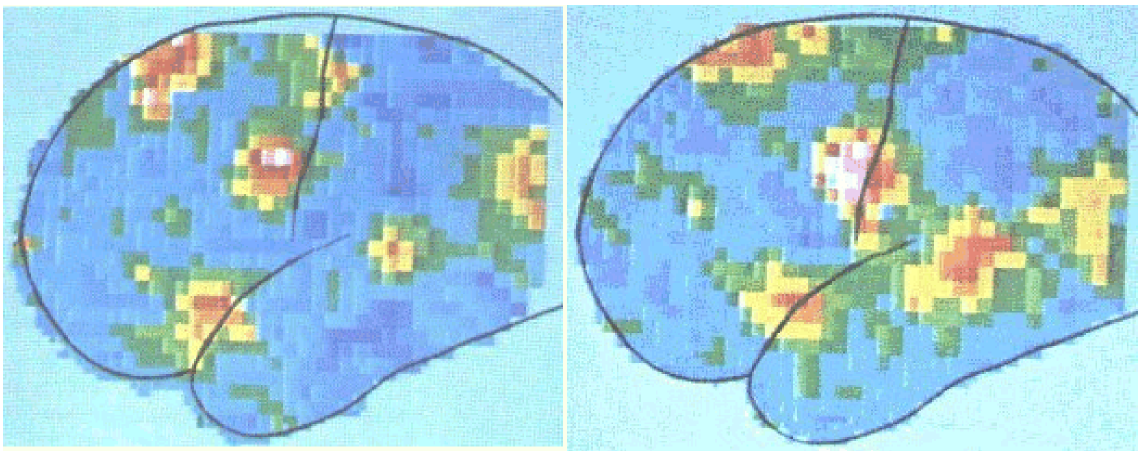

Figure 12: Blood Activity Level in the Brain when reading silently (left side) and aloud (right side)

Vester [Ves78] introduces a distinction of four learning types: auditive, optic/visual, haptic and one type that learns by intellect. From a physiological point of view, this distinction does not help a lot: in the learning process of building associations to already existing knowledge the brain will use the applicable and most effective channels. Their usage is adapted to changing environmental situations and internal, physical conditions.

Network Stimuli

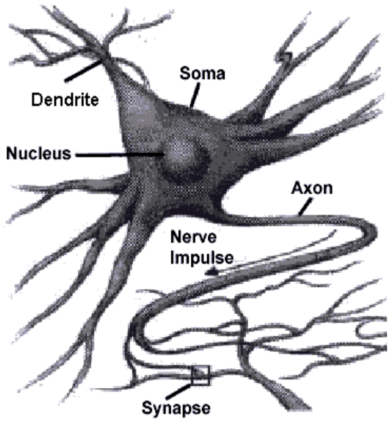

Figure 13: Neuron and Nerve Impulse

Information processing in the brain.

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Learning occurs by modification of neural structures: Birth or death of neurons, synapses emerge, are amplified, degenerate or disappear. As a simple analogy neural nets are compared to the functionality of – classical – computers, based on a straight-forward linear signal processing. Velocity of signal propagation is relatively slow. Compared to computers an immediate reaction based on a strictly linear propagation is insufficient for acting successful in highly dynamical environments.

The linear electrical signal forwarding in the neural net is relatively slow but dynamically changing environments demands fast information processing to react immediately.

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Non-linear and highly parallel ways of signal transmission enable highly efficient information processing.

In nature non-linearity and parallelism are fundamental in networks of information and signal processing units: in the microscopic world of neurons as well as in the macroscopic world of social or economic networks. The latter world seems to be determined by the characteristics of the first one. Signal propagation is based on chemical processes, which are additionally influenced by the surrounding level of other chemicals: hormone, drugs, etc. Medical treatment, drugs, alcohol as well as moods and stimulation are responsible for those levels.

You as an individual as well as a teacher should be aware of the chances and risks that lie in this fundamental way of information retrieval and processing.

Information processing and learning in particular can be supported by e.g.

- positive base mood
- pleasant workplace / room / working environment
- variation of exertion and relaxation
- taking track of physical influencing factors (fresh air, light, biological rhythm, etc.)
- variation of tasks and alternating use of both sides of brain

When a connection is used frequently enough it becomes more stable or even permanent.

You as a teacher should bear in mind that abilities and information learned need to be triggered frequently. Biological processes are the reason for the importance of repetition in learning and training.

In the microscopic world of neurons signal propagation is based on the excitement of the input side of a neuron – dendrite – by a certain presence of recognised chemicals. When enough dendrites get excited, this triggers an electrical impulse in the cell, where they are processed.

Dependent on the activation of the cell and its processing function an outgoing electrical impulse goes down the axon resulting in a release of chemicals at the end points – axon terminals. Chemicals flow across the synapse and excite dendrites of other neurons.

Brain, learning and behaviour are mutually dependent and affecting: learning and changing of behaviour modify the neural structure, changes in neural structure alter learned content, the way of learning and applying knowledge.

* * *

Implementation examples:

- *Serve a cup of coffee / tea and some cookies may support the brain biologically and create a pleasant situation, too ("Do Food" pattern in [MR01])*
- *Alternate left and right brain activities.*
- *Do physical work ("hand craft") after or between mental work ("brain craft").*

PERCEPTIBLE PROCESS AND RESULT

Figure 14: M. C. Escher: Drawing Hand

Motivation in processes with non-physical results.

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In nature, all forms of life must prove themselves in a material environment. The process of interaction with objects in the environment, their modification and the results of such processes manifest themselves physically.

Abstraction of real objects is fundamental for the origin of intelligence. The real world is modelled by means of names, concepts and their associations. The process of creation or modification in the intellectual world as well as results of such processes are immaterial. Nevertheless, determined by evolution, human actions basically aim at changing physical objects and results of that kind.

Our cognitive system was originally designed for processes and results of a physical nature but intellectual work does not create physical results directly.

* * *

You should make it possible for the process and the results of intellectual work to manifest themselves physically or associate it to the material world. Make intellectual work and their results perceptible!

You as a teacher should bear in mind to include the physical manifestation of processes and results in courses.

Possibilities are nicely printed book-like documents at the end of a course and hand-written project plans on the wall, where the project process is visualised by marking the process state by hand.

For example, a meal or party of the team members allows them to associate a reached milestone as a result of intellectual work to physically perceptible things.

You as a learner should reward yourself when you have reached a goal or milestone.

Make your intellectual work tangible e.g. by printing out your work, writing down notes about your goals and steps achieved towards them.

Rationale

> *The will to immortality combined with the picture of the world drawn above can lead him to just one goal: to make his own personal contribution to cosmic evolution, to externalize his personality in all subsequent acts of the world drama. In order to be eternal this contribution must be constructive. Thus we come to the principle that the Highest Good is a constructive contribution to the evolution of the universe. The traditional cultural and social values may be largely deduced from this principle. To the extent that they conflict with it they should be cast aside as ruthlessly as we suppress animal instincts in the name of higher values. The human being continues somehow to live in his creations... [Tur77]*

* * *

Humans like printed documentation or publication instead of online versions not only due to the fact that they can be read nearly anywhere: paper is tangible. A book as a physical existing "thing" provides authors the feeling of being a creator much more than a online publication can do.

Hand craft drawings, e.g. mind maps on a flip chart, involve more parts of the body and allow more degrees of freedom than the usage of the hand-eye system necessary to write or paint on a computer. An example is the use of CRC-cards in requirement engineering.

The author remembers an acquaintance, a retired bookkeeper, who, before writing down something, first slowly sharpened his pencil with pleasure - even if it was sharp enough. This process had something of a ritual about it. Although part of an intellectual working process, this provides tangible impressions: the physical work , combined with the smell of cedar wood and paint.

SMOOTH INCREASE OF KNOWLEDGE

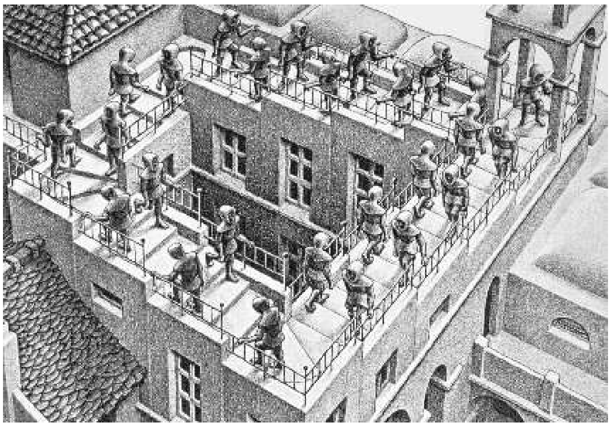

Figure 15: M. C. Escher: Detail from Ascending & Descending

Learning and teaching of new topics.

* * *

Knowledge increases by evolving new models of reality; i.e. the process of cognition. Building new models is hard and resource – time, effort – consuming. A principle in nature is efficiency. Increase of knowledge by evolving new models in unknown situations is inefficient in the long term.

To acquire knowledge in new topics is hard or even impossible without connecting points in the associative net of the the long term memory.

* * *

Effective knowledge acquisition starts from a known area and performs a stepwise transition to other area building up new associations.

Possible transitions are:

- LEARNING BY ANALOGY as a horizontal movement to a new area of knowledge or
- GENERALISATION AND REFINEMENT as a vertical transition in the same area of knowledge.

These two fundamental ways of acquiring knowledge can be illustrated as transitions in a plain of knowledge areas (areas in the field of associations of models of reality) shown in the figure below.

Different knowledge areas are organised along the horizontal axis. The level of abstraction is assigned to the horizontal axis. In this model LEARNING BY ANALOGY can be seen as a movement parallel to the horizontal axis and GENERALISATION AND REFINEMENT as a movement parallel to the vertical axis.

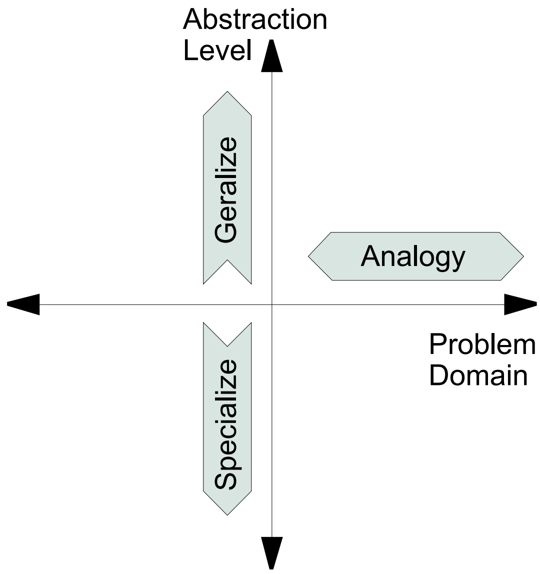

Figure 16: Plane of Knowledge

You as a teacher should first try to find a well known area of knowledge and experience similar to the area you want to achieve.

When teaching a group this area should be shared among the learners as widely as possible. Help the learners on their transition by pointing out structural and functional similarities e. g. by giving possible different examples that have these structural and functional similarities in common.

Learning by analogy is fundamental for human beings. It is simulated by an artificial intelligence technique: Case Based Reasoning. Generalisation is the basis concept in many disciplines: e.g. mathematics or computer science.

* * *

ARC OF INTENTION

Figure 17: Stari Most ("Old Bridge") of the City of Mostar[2]

Situations in which content has to be transferred to a group of human beings that are present – presence transfer – or are reached via media like printing or electronic infrastructure – non-presence transfer.

* * *

People who are highly interested or working intensively in a specific domain are able to grasp information on a very detailed and deep level. If the target group is not so deeply involved or is heterogeneous to jump into the middle of a topic may leave a larger part of the audience not involved. Such a feeling may result in a lack of interest on their part. If the audience is not present authors only can assume the state of knowledge and experience in the actual topic.

To transfer specific content to a real-time audience or one separated in time or space needs a shared conceptional model which cannot be taken for granted generally.

* * *

To answer this question one should consider that at the starting point the author has to receive the audience at a level that is shared to a large degree by everyone. Stepwise transitions have to be performed towards the deep and detailed part of the topic to be achieved, which may be new to the audience.

The rate of intention decreases in this process until the main issue is presented. Stopping there would cut short the process. Thus, you should provide ways to return to already known areas to support building up new associations to existing representations leaving the audience with feeling of satisfaction.

The whole process can be seen as an ARC OF INTENTION, as shown in figure 18.

You as a teacher or presenter should plan and prepare speeches, presentations and

2The reconstruction of this bridge is a UNESCO project. Information from the related web site (http://www.unesco.org/opi2/mostar): "The bridge was built ... in 1566 by a Turkish architect under the Ottoman Empire and is of exceptional artistic and structural value. The 27-meter-long arch has resisted 427 years of invasions, wars, and natural disasters and has become a powerful symbol during the years of the conflict. Its deliberate destruction on 9 November 1993 came as a profound shock to the population of the country which saw the bridge as a symbol of peace and reconciliation between the peoples of Bosnia and Herzegovina,..."

papers in such a way that the audience is led to the top of the ARC OF INTENTION, is keen on achieving the (re-)solution and then can "calm down" back to a narrow level of intention.

You as a learning individual should be aware of the ARC OF INTENTION when organising your way to acquire knowledge in a new area.

* * *

The ARC OF INTENTION has been widely used for hundreds of years: e. g. in rhetorical instructions from the ancient Greeks, dramaturgy in theatre science, etc.

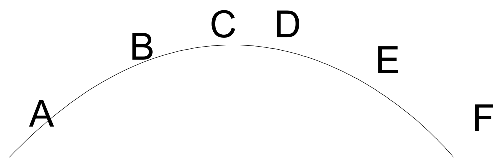

Figure 18: Arc of Intention for Patterns of this Collection

The Alexandrian structure of patterns used in this pattern collection follows the ARC OF INTENTION. The elements are as follows:

Element	Name	Function
A	Context	Getting the interest of the reader and setting the context
B	Forces	
C	Problem	Summary of the forces on top of the forces and the arc of intention
D	Solution	Solving the problem and resolving the forces
E	Rationales	Elaborating the solution and giving detailed background information
F	Examples, Known Uses	further de-stressing of the level of intention and providing bridges to already known topics or own experiences

The turning points are market with three stars dividing four parts: A, BC, DE, F

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5 after [Ras83]

6 from [Tur77]

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