Proceedings of the conference

PROBLEMS OF OF CONTEXT

Amsterdam, 17 - 19 april 1979

VU Boekhandel, 1980

★

edited by

Gerard de Zeeuw and Pieter van den Eeden

Problems of context in teaching systems behaviour

A.A. Verveen

Introduction

In teaching physiology and pathophysiology of living systems to first year students in medicine, one has to teach system structure and function in health and disease. One of the main problems a teacher then faces is the fact that he has to take into account the pre-existing attitudes and beliefs of the students themselves. In the course of their education at home and in school they absorbed a collection of ideas and approaches, which are at varance with the reality posed by the behaviour of complex systems such as organisms. This knowledge is most difficult to unlearn. The teacher, therefore, not only has to teach, but he even has to go into pains of guiding them in step-by-step unlearning processes. One cannot proceed by considering the students to be blank pages to be written upon from scratch. One has to try to eliminate pre-existing scratches and give meaningful lines instead. But a prerequisite is to know in advance what those scratches are. Many lay quite deeply embedded into our culture. This implies that one cannot simply tell that "such-and such is not true". Intellectual and logical procedures do not work in situations against pre-existing beliefs and attitudes: the eye does not see, the ear not hear, the skin not feel, and the mind not think but what it has learned to see, learned to hear, learned to feel and learned to think, i.e. learned to believe. The student can only work within his/her context and start from there. Our approach, therefore, has (to put it strongly) to be contextual first and intellectual afterwards. This already goes against the grain, as is stated in the dogmatic Dutch proverb:

'Eerst gedaan en dan gedacht, heeft menigeen in 't leed gebracht'

freely translated by:

'Done first and later thought, brought many nought, or even worse'

(i.e. think, before you act).

Instead, the method of learning by trial and error ("Do first, then think about it") is quite powerful and should be used fullscale by the teacher, long before he has to explain this method to the students. In such a way they get used to this approach and evaluate its sense before they are able to connect it to the dogma expressed before. They may then be able to reject the dogma.

Examples

To apply this to a full classroom (of about 150 students) one asks the students to observe their own behaviour, that of their neighbours and that of the whole class to a diverse set of simple experiments: each at the relevant part of the course, and some with the use of candid camera TV registration of the behaviour of the class, followed by immediate replay.

Thunderclap

The reaction of each individual and of the whole population to an unexpected thunderclap in the room (with the use of a piece of firework) demonstrates system behaviour: reaction-time, fright reaction, inspection reflex, optimalization (the head is turned around along the shortest path) and relaxation-time (of the level of the sound produced by the students upon the sudden disruption of the lecture by the clap).

"Stand up, please"

Another example is given by their response to the unexpected but serious quest by the teacher for all to stand up. On the individual level hesitation is present, which then can be pointed out to be a stochastic aspect of our behaviour with time and can be described by a relatively simple approximation. The resulting emotional involvement in such types of experiment on system behaviour acts as a strong motivational aid in the study of systems, also since the application or explanation is nearly immediate.

Pain

Past experiences

Another, additional, approach is to use past experiences which are quite clearly present in their minds. Such as reactions to cold or warmth thermoregulation, or the absence of responses to damage when preoccupied, in teaching on noxe and pain. One here stumbles upon another dogma:

"damage 'is' pain", and "pain 'is' damage",

which is quite deeply rooted, notwithstanding their experiences of wounds, blue patches or burns discovered long after the instant of damage.

Learn not to feel pain

The next step: that you are even able to learn not to feel pain to a specific kind of damage, is so difficult to take that actual demonstration may be necessary (an unesthetised burn with a solder iron). I do not know whether some students then also are able to learn this, but the experiment and its emotional context (the observers 'feel' the pain, which the unanesthetized teacher-victim does not) provides sufficient material for the students to at least gravely doubt the validity of the dogma.

Open Loop thinking

With regard to the teaching of the function and structure of the simple feedback systems the same rule applies: first let the students experience system properties in actual practise, then explain. This is even more stringent, since the structure of their thinking processes acquired at the elementary and high school is, again, quite dogmatic:

'an exclusively monocausal and single-line open-loop approach is the rule'

The 'backward' cause-effect relation in feedback is alien to them, where the more intuitive appraissal of the existence of vicious cyles is of no help. A nice experiment is the observation of the behaviour of each others pupil diameter upon slow and fast changes of the light intensity within the room.

Such experiences are followed by step-by-step explanations and combined with comparable experiments. In this way the students obtain both a working and an intellectual familiarity with systems behaviour at the basal level.

Feedback is 'good'

In a similar way one has to attack the new dogma:

'feedback is good'

'and should be installed everywhere',

in blatant neglect of the grave and often fatal consequences of such a simple approach. Within the last decade Universities within the Netherlands have unduly suffered under such an approach by the generation of a quickly conceived governemental law on democratization at the Universities. This law neglected the creation of filters (such as cooling off periods to slow down the cycle-time) to prevent the effects of positive feed-back. Disastrous effects did occur, of course. These varied from local disturbances in laboratories and in faculties up to the disappearance of the board of one university for a long period of time (more than one year).

These effects falsely led to the idea that the concept behind the law is wrong. Here, again insight into the behavior of simple feedback systems within the population at large is lacking. I wonder when systems behaviour will be taught at the high school level and, even, at the level of the elementary schools. This then will enable the individual citizens to evaluate political structures. Decisions to be made by the population at large might then become more balanced. The future of democratic systems may hinge upon just this kind of approach at the schools.

Government

Basic ideas about the funtion of government can, for example, be obtained from a simple systems approach: Within the government at large (the red big box of Fig. 1) laws and plans x are created by the government G, to be executed by its departments (D). When the population C has no say in government (C=0 and parliament P does not exist or is effectively barred from C: closed doors in Fig. 1) then the result y will be determined by the power (gain) D of the dictatorial government.

$$y = Dx$$

Therefore, y will be larger than x; often very much so dependent on the size of D. The dramatic results are well known. They may be visible for centuries, such as extravagant palaces built at the expense of the powerless population C. When the citizens have a say in the matter,

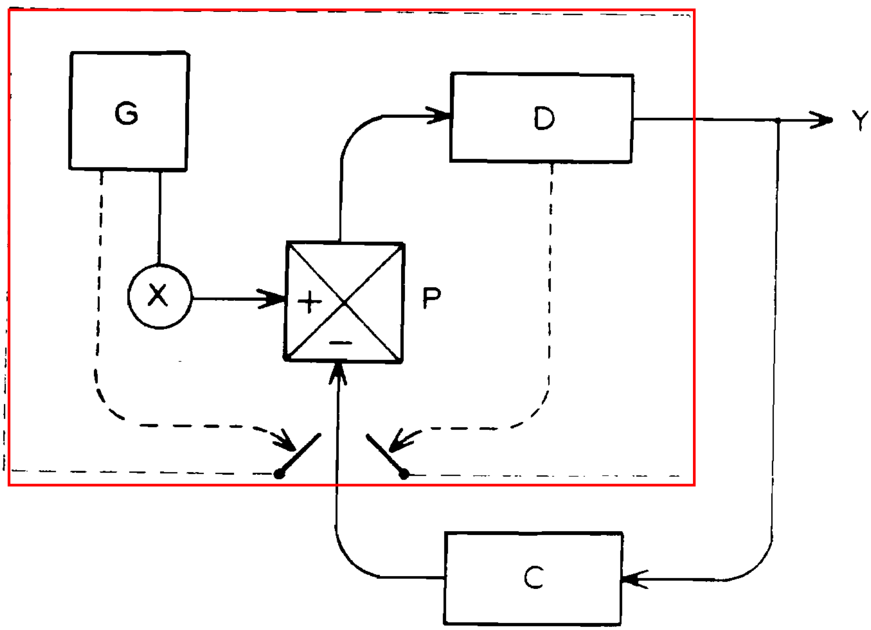

Fig. 1. Government of a state or other organization.

The government at large consists of the government G, parliament P and executive organs (departments) D. C are the citizens of the state or the members of the organization. Laws and/or plans x and their result y. See text for further information.

then

$$y = \frac{DC}{1+DC} \cdot \frac{x}{C}$$

i.e.

$$y = \frac{x}{C}$$

for values of DC that are not too small i.e. the government must be powerful. This implies that even a small but effective democratic structure might work quite well, and that the activity of action groups makes much sense. Then the execution of plans x is controlled: approved plans will be neatly executed with minimal control $(C = 1)$. Other plans may be quenched effectively when they do not fit into the context of the population: C is raised and y approaches zero. This calls for a structure with variable feedback C, such as exists in the chosen delegates of parliament P. A 'one-man-one-vote for all x' system (democracy by referendum) does not work, since for such a large size of C the values of y will always be about zero. Hence the fear - and rightly so - of company boards for local democratization (of this type!), since a large value of C abolishes all developments. Hence the activity of governmental organizations within both large and small scale democratic systems to curtail the input (feedback) from C (dashed lines to the 'doors' for C in Fig.1):

- the boss is not at home or in his office when a delegation wants to talk to him,
- or he is present, but talks all the time,
- the delegates are snowed down with paper-work ('xeroxdictature'),
- hearings are convened within too short a span of time,
- hearings are published in insignificant parts of the daily journals,
- the judges are not independent,
- and so on.

These techniques should also be known, for C to develop effective countermeasures (such as the formation of action groups).

Variability

Back to freshmen, another contextual problem is given by the concept of variability. Here the problem also rests upon a relatively new dogma:

'variability should not exist',

which manifests itself in many different ways. Within a political party different opinions may not be allowed, for istance; government should be monopolitically structured; differences in ability should should not exist. But also practical: this dogma (reinforced by the popularity of small-systems sciences such as physics) must have given rise to the pseudoscientific and in fact mythological reign of the socalled 'hard facts' in medicine.

The heart rate

An example is given by the following classroom experiment. Each year the freshmen in medicine are asked to write down the reference heart

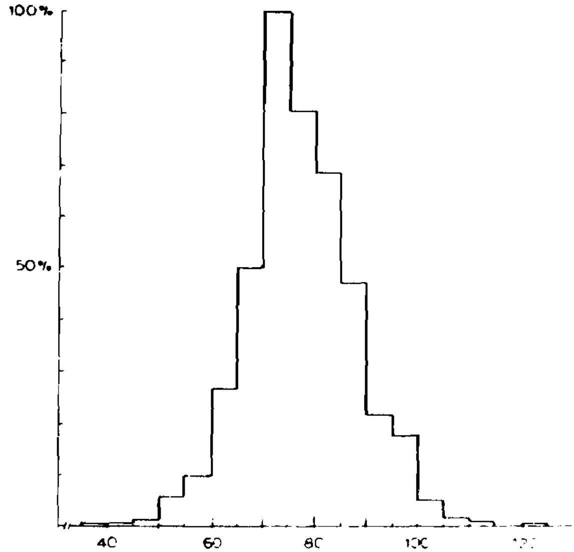

Fig. 2. Distribution of heart rates for 768 first year students in medicine, measured in the sitting position. Expressed in percentages of the mode.

rate of a (future) patient. About 95 out of 100 students then write down a single number. They then are taught to measure the heart rate. This is followed by the actual measurement, each by him- or her-self. The data are then also recorded and plotted (Fig. 2). The students are thus all confronted immediately with the divergence between their ideas on "the" reference value and the actual situation within a population of healthy persons.

The fallacy of the mean

Taught in this way, they will never forget the experience. They then must be able to circumvent the "fallacy of the mean". In my opinion practical statistics as such places undue attention upon the behaviour of mean values.

The variability is averaged away, while lipservice is paid to the variance. I am of the opinion that 95 or 99% ranges should be calculated straight away, and also tabulated; the practise of data representation by mean ± (one or more times the) standard deviation should be abandoned. Otherwise the undue attention to the behaviour of the mean stays with us (see also Mosteller and Tukey, 1977). A similar situation operates in present Dutch politics, where salaries are compared with that of 'the modal man', with neglect of, say, 50 and higher percentage ranges. The characteristique: 'modal', will most probably become emotionally loaded and transformed into a quality: something that has to be attained by everyone. Here again, variability will become considered to be unwanted phenomenon.

The chair

Another nice example is "the Chair". Chairs are mostly designed for one way of sitting, of use. Many ways of sitting in chairs and of other functions of chairs have to be kept in mind, however (Boekholt, 1979).

Age and function

An example of false asumptions and beliefs is given by the present approach to old age:

'Older persons lose abilities'

and all the consequences of this way of thinking. In the physiology of ageing this tendency also appears quite explicitely in the studies of organ functions as related to chronological age.

Gain versus age

In Fig.3A a physiological gain function (one may for instance think of lung capacity) is sketched as a funtion of chronological age. Here only the relationship between mean and age is given, which neglects the variability mentioned above. A better sketch is given in Fig.3B, where 90% ranges are sketched, and the mean is left away. Such a measure does not tell us anything about what we usually need in ordinary daily life with respect to age. It also does not give us information on the minimal gain: the gain value below which we cannot function adequately anymore. Here, as in the examples on 'heart beat' and chair', we forget the far more complex system of which this organ forms a part (granted that it is far more difficult to measure the more complex behaviour of the whole system as a function of chronological age). A property

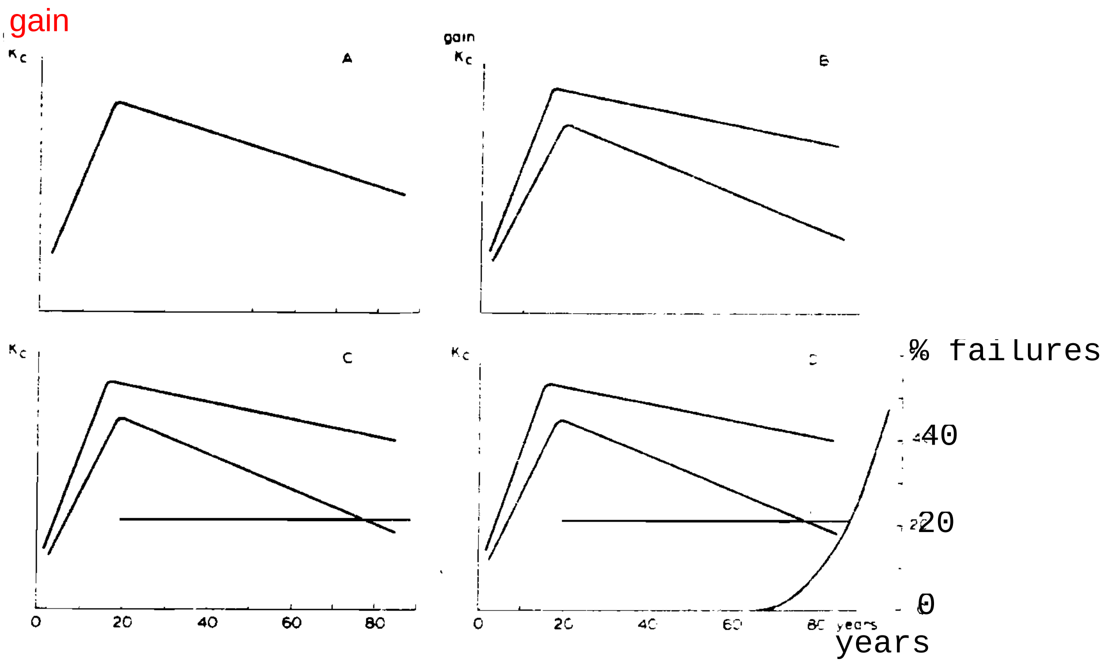

Fig. 3. Gain versus age. For explanation see text.

such as lung capacity may play a role in the gain of the control system for the regulation of oxygen and carbonate levels in our blood. A zero-order approximation to the regulation of the individual blood oxygen level may then be given by

$$O_{2,act} = C.O_{2,ref} \qquad \text{with } C = \frac{K_c K_o}{1 + K_c K_o}$$

Here K_c is the gain component related to lung capacity, K_o are other gain factors, $O_{2,ref}$ is the reference and $O_{2,act}$ the actual oxygen level in the blood. Given a minimal actual oxygen level necessary for daily life, the lung capacity may decrease quite much before deleterious effects occur. The coefficient C is hardly sensitive to changes of the gain factors, unless the decrease is too drastic. We may all know this from experience, since a loss of one lung, or one renal, even of one eye or ear, does not lead to real invalidity.

Functional redundancy and age effects

We therefore have a functional redundancy in our organ-proporties, which is called the functional reserve. Given a minimal value, we may draw such a line into Fig. 3B, which gives Fig. 3C. From this figure we then draw a graph of percentage failure in relation to age. The fraction of failures then stays at nearly zero % through all ages but for very old ages (Fig. 3D). This picture is far less dramatic. It also gives us meaningful information: only above a certain age level (an increasing) fraction of people will become ill due to a gain decrease below the minimally required one (or before that time because of certain fluctuations) (Strehler, 1962).

This example shows that a systems approach is essential in the evaluation of complex processes and that a simple evaluation of functions or organs in relation to age may lead to unwarranted conclusions.

The effect of age-cohorts

There may exist another, basic, flaw in the representation of Fig.3, however: a confusion between transversal age-related measurements of a population and longitudinal life-history-related data for a parameter. In transversal measurements the data for a parameter are measured at one moment in time for a population. Afterwards the data are related to the different age-groups in this population. In longitudinal measurements each individual of a population is followed during his whole lifetime. The latter are far more difficult to obtain, and one therfore often has to fall back upon transversal population measurements. To make this point clear I will use the following construction, where I sketch body length as a function of age in a thought experiment (Fig. 4). This graph suggests a relationship between length and age for a population. One knows, however, that adult length does not, or only quite slightly decrease with age: the longitudinal parameter does not change with age. One does not fall easily into the trap given by Fig. 4, but one does so immediately with regard to Fig. 3A and B. The lesson of Fig. 4 is that different age cohorts grow up under different circumstances and this aspect needs to be eliminated in all age-related graphs, which is often not or hardly possible.

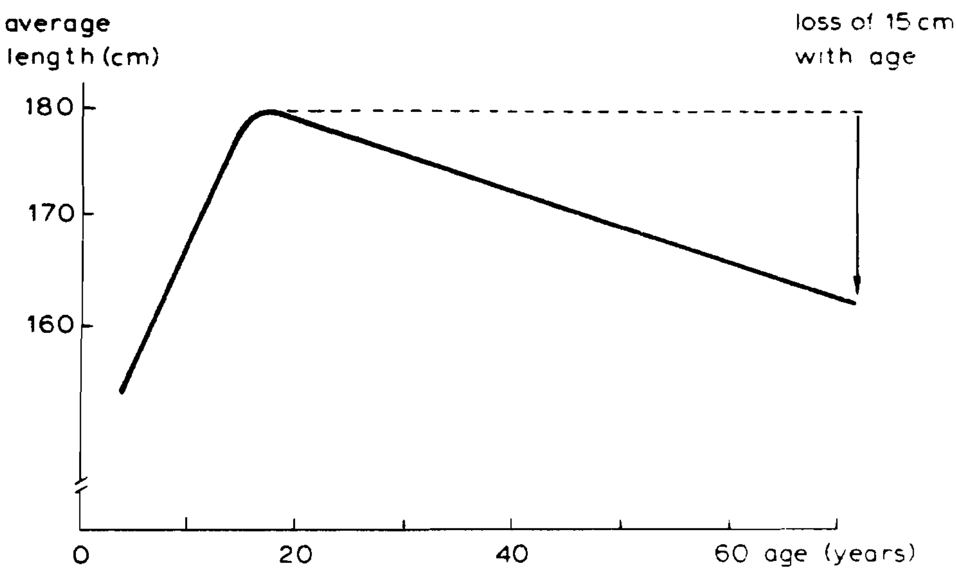

Fig. 4. Distribution of average body length with age (imaginary data).

Myths of ageing: self-fulfilling prophecies

The neglect of life-history also manifests itself in another way with respects to age. When people really believe dogmas such as:

sex decreases with age,
above forty years of age one's abilities go down,
one cannot work above 60 or 65 years,
great scientific breakthroughs are done only by people in their twenties

(and one can easily extend such a list of myths), then the effect will be that many people do conform to these 'standards'. Investigations of organ functions then will show the results of disuse, since disuse leads to organ atrophy or dysfunction. A decrease of function which is, then, age-related in a real way, may not be physiological at all, but sociologically induced. This is an important trap into which one may tumble. The more so since these findings then confirm pre-existing dogmatic beliefs. In reality these results point to the adaptive properties of complex biological systems.

Problems of context

the very complexity of adaptive systems (such as ourselves) which generates its own problems of context and which will continue to generate new contextual problems:
From curves such as that of Fig. 3 one easily tends to idealize the age of adolescense. Note that this process is reinforced by the widely advertized, but incidental, achievements in specialized fiels such as athletics.
The fight against debilitating diseases in medicine has resulted in a paradoxical situation: small ailments and minor misadjustments become intolerable. Note, for instance, the emergence of wholescale advertisements of painrelieving drugs on TV. The drive against body odours is another example.

Vicious wellbeing

The absolute nature of the ideas behind the concept of 'well-being' may trigger a vicious cycle in which well-being annihilates itself and our dependance on medical treatment will grow beyond all bounds (Illich, 1976).

For the problems sketched here, a general education of the whole population in the basic ideas of systems theory may, therefore, be one of the approaches necessary for our survival.

References

Boekholt, J.T. Growth and the design of morphological systems. These proceedings, 1979.

Illich, J. Medical Nemesis. The Expropriation of Health. London: Random House, 1976.

Mosteller, F. & Tuley, J.W. Data Analysis and Regression. Reading, Massachusetts: Addison-Wesley, 1977, Ch. 1 and 2.

Strehler, B.L. Time, Cells and Aging. New york & London: Academic Press, 1962.

Wohlwill, J.F. The age variable in psychological research. Psychological Review, 1977, 77, 49-64.