Computersimulatie en wiskundige modellen in het medisch onderwijs : het RL-computersimulatiesysteem

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Summary and conclusive remarks

The use of computers in eduction has experienced an explosive development during the last years. There is still much research going on as to the choice of computer configurations, proper software adequate learning programs etc. One of the approaches to the application of computers in education is the use of one of the strongest features of the computer, viz its power to perform simulations of complex systems. This thesis describes a study on the development of a computer simulation system for the simulation of biological processes to be used in a problem oriented medical curriculum.

In chapter 1 the most important domains of this study are introduced: (a) the role of the computer as an educational appliance. More specifically the developments of "Computer Assisted Instruction" (CAI) are briefly introduced; (b) simulation is introduced as a method in education. The possibilities of computersimulations on the basis of mathematical models are discussed from the point of view that this approach allows the study of fundamental concepts underlying complex biological systems; (c) the specific educational environment at the University of Limburg (RL) is introduced. The specific features of the problem-oriented medical curriculum are discussed.

The first part of chapter 2 discusses methods of mathematical modelling and simulation of biological systems. In the second paragraph of this chapter arguments are discussed that led to the realisation of the RL-computer simulation system. Specifically the choice of programming language, terminal system, computer configuration, machine-student adaptations, response-times and ergonomy is argued. The last part of this chapter describes the RL-computer simulation system to be used in later chapters in combination with different mathematical models. The hardware of the system is discussed as well as the software, the individual modules and files of the system.

Chapter 3 describes the results of implementing a mathematical model on basic hemodynamics into the RL computer simulation system. This program -AORTA- allows students the study of basic hemodynamic relations between pressure, volume, flow, resistance and compliance. The model is based on a "windkessel" model of the aorta. It allows simulation of the effects of hemodynamic disturbances on the pressure and flow in the major arteries.

Chapter 4 presents the results of CARDIO, a simulation program on blood pressure regulation under normal and abnormal conditions. The model underlying this program is a more advanced model of cardio-vascular control than that used in AORTA. It allows the simulation of pathological conditions, such as myocardial infarct, renal artery stenosis or renal insufficiency. On the other hand therapeutic interventions in abnormal conditions can also be simulated. The program allows the application of drugs like cardiac glycosides, diuretics or vaso-dilators.

Chapter 5 describes the computer simulation program FLUIDS. The mathematical model underlying this program contains over 200 variables and describes control mechanisms of body fluid volumes and electrolytes as well as respiratory control mechanisms. This models allows a variety of simulations of e.g. thirst, fluid loss, exaggerated drinking, carbon dioxide inhalation, severe physical exercise etc. Again, students can also intervene therapeutically in an abnormal steady-state of the model by infusing fluids of different composition, giving a diuretic etc. The basic physiology of respiratory and metabolic acidosis and alkalosis can be studied with this model.

Chapter 6 contains a description of a two-compartment model underlying the computer simulation program FARMA. This program allows students to become conversant with basic pharmacokinetic principles such as the half-life, clearance of distribution volume of a drug.

In chapter 7 the more detailed pharmacokinetic program MACDOPE, which was originally developed at McMaster University in Hamilton, Canada, is discussed. This program is analyzed with respect to the structure of the model, thus allowing implementation into the RL computer simulation system. Moreover, a number of experiments on the pharmacokinetic behaviour of acetylsalicylic acid and ampicillin in different patients are presented.

Chapter 8 discusses the computer simulation program ANAMNESE. In contrast to all other programs ANAMNESE is not based upon a mathematical model.

Rather, it simulates the anamnestic interview between a doctor and a patient. This program contains a large data file with patient characteristics. The student can take the medical history of a selected patient only by systematically going through the relevant questions. Two examples of different patients are discussed in this chapter.

Chapter 9 discusses the computer simulation program ENZYM. This program simulates the basic Michaelis-Menten kinetics of an enzyme reaction.

In chapter 10 the use of the different computer simulation programs of the previous chapters in the medical curriculum is discussed. The use of the different programs in the various years is presented. Furthermore the "behaviour" of students in computer simulation sessions is discussed, specially in relation to the changes they make in the models. Next, some preliminary results are discussed on the appreciation of the programs by the students, as well as the influence of some of the programs on their level of insight in respective problems related to the simulations.
It is concluded that there is a clear place for computer simulations as an educational tool in the medical curriculum. The frequency of use as well as the appreciation by the students shows the value of this tool. The general RL computer simulation system is a versatile program, allowing the introduction of a wide variety of mathematical models and simulations in a curriculum.