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CENTRAL RESEARCH INSTITUTE FOR PHYSICS

BUDAPEST

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Abstract

The report gives a mosaik-like summary of the activities of the Central Research Institute for Physics of the Hungarian Academy of Sciences in the field of education by minicomputer.

Резюме

В данной работе дается мозаичное суммирование о деятельности Центрального Института Физических Исследований Венгерской Академии Наук, осуществляемой в области образования с помощью мини ЭВМ.

Kivonat

A report a Magyar Tudományos Akadémia Központi Fizikai Kutató Intézetének a számitógépes oktatás terén kifejtett tevékenységéről ad mozaikszerü összefoglalást.

The Central Research Institute for Physics /Hungarian abbreviation: KFKI/ of the Hungarian Academy of Sciences was founded in 1950. At the beginning of 1975 it was designated a research centre consisting of four scientific institutes:

- the Research Institute for Particle and Nuclear Physics
- the Institute for Solid State Research
- the Institute for Atomic Energy Research
- the Research Institute for Measurement and Computing Techniques

The strengthening of the bonds and the forging of closer links between science and its practical applications form one of the main tasks of KFKI. This task is a highly complex one involving close cooperation between the various disciplines. Just one or two examples serve to reveal this: ion-implantation, a key technology of modern semiconductor manufacture has developed as a result of the interaction between nuclear and solid state physics; up-to-date analytical chemistry is based to a significant extent on nuclear physics. A prime example of the link between science and industry is in the Danube Iron Works - a renowned industrial plant - where the oxygen content of steel determined in an activation analysis laboratory set up by us. In agriculture, the overwhelmingly important production and consumption of proteins are controlled by means of a fast and reliable analytical method, and the results of soil samples are processed by computer system... .

Purely from our own experience in KFKI it is self-evident that scientific results cannot be achieved without up-to-date <u>measuring techniques</u> in experimental work. Our techniques were developed in self-made style and not brought in from outside since the purchase of up-to-date equipment was rather difficult at the beginning of the fifties and every new experimental work demanded not only new ideas but new measuring methods and devices too.

We were thus forced to develop our own research into measuring techniques. An Electronics Department staffed by specialized engineers was founded; initially this was of a servicing nature, later it became an independent scientific branch. At the 25th anniversary celebration of the Institute our Director General L. Pál, Member of the Hungarian Academy of Sciences, remembered those times saying "... KFKI has become the most important foundation stone on which national measuring techniques are built and this is due to this determination..". The Electronics Department was the seed which was nurtured and has grown into the Research Institute for Measurement and Computing Techniques.

Research into measuring techniques has been stimulated by the nuclear research reactor installed in 1959; the installation provoked the manufacture of Hungarian nuclear measuring equipment. Some of products contained highly significant technical concepts. At the beginning of the sixties most manufacturing work was handed over to industry for production. Since that time a new demand by the physicist has arisen: the demand for the maximum possible amount of information to be collected and preprocessed. This characterized the next "era" of electronic development, the era of the so called multichannel analysers. The first 128-channel electron tube version was followed by 256-512, and 1024-channel equipment, built using second generation technology.

The members of the analyser family have been utilized not only in the Institute; the list of users is considerably lengthened by other Hungarian, and foreign academic institutes. The small series production of analysers presented KFKI with other viewpoints: particularly that of user experience. New demands shaped the next phase of research and development activity. In 1970 the production of multichannel analysers followed the path to industrial firms taken by nuclear measuring equipment. /It must be mentioned that this has not meant the end of development and experimental production of multichannel analysers since our third generation products - the ICA-70 multichannel analyser and the NIA-200 stochastic analyser - are bestsellers nowadays./

In the middle sixties our experimental physicists became inundated with a flood of data due to the complexity and precision of their measurements and the wired-logic devices: data processing was drastically slowed down and almost came to a standstill. The complexity of digital measuring equipment pressurized the need for a measuring and data processing system. Such a system could not operate without a stored program analyser and the TPA /Hungarian abbreviation of stored programm analyser/ was born. At that time such types of equipment were called minicomputers.

The enthusiastic group with experience in digital equipment design and production had begun the development of the first Hungarian minicomputer. The past experiences of KFKI and clear situation analysis had prepared the way for a definite choice: a system compatible at program level to the PDP-8 minicomputer - a very successful and universally used small machine - was needed.

The year 1968 saw the completion of the second generation TPA-1001 computer long awaited by the cooperating foreign academic institutes. In a very short time 40 complete systems were installed and in use.

Technological development enabled reduction in size; the reliability of the devices, however, was increased.

The TPA-i, the third generation, is one of the most popular computers in socialist relation with more than 200 systems having have been produced up to 1977.

Its advantages:

- world-wide outstanding supply of basic and operational programs and continuously expanding user's program
- compatibility of highly different peripheral devices with the main frame
- perfectly organized input/output system
- technical parameters corresponding to the requirements of the user's field
- easy handling possibility and relative cheapness
- production and application both offer immense advantages in the enlargement of computer techniques, and in the domain of specialist education.

While the TPA-1001 was used almost exclusively as stand-alone equipment for technical-scientific calculations, in the application of the TPA-i, a significant change of profile can be observed.

Almost without exception the TPA-i small computer is utilized as a component part or the control-element of a complete system.

What are these systems? The following list is by no means exhaustive:

multi terminal educational system; communication system provided with remote multiplexer and data remote transfer units; intelligent terminal; business-oriented data processing system with fast, high capacity peripherals; real-time peripherals; also the CAMAC system realized for industrial or laboratory measurement and data collection.

The continuously increasing demands required the development of the computer family TPA-70 and TPA-1140 necessary. /The industrial production of TPA-70 started in 1976./ Besides TPA-type computers and systems design, KFKI today undertakes the production of its own units with a delivery date of 9-12 months from the contract agreement.

KFKI provides details of other users enabling would-be users to gain first hand information and arranges, on demand, tuition in the use of TPA machines.

Here are just some of the devices of KFKI computing techniques:

NE-601/i raster system display
Console display of type Pi-12F- ...
Pe-12F microprocessor controlled intelligent graphical display terminal /for any type of computer/
NC-245/i disc control unit
NE-622 TPA-i / DISCMOM controller
NE-646 DISCMOM controller family to the PDP-11 compatible computers
NC-256 controller units for floppy discs
NE-620/i... magnetic tape system interface family
NZ-669/70.. magnetic tape system interface family

Other interface-control units of peripheral devices
Interfacing of TPA-type small computers to small, medium and large computers
Microprocessor system built on TPA-type small computers
Computarized mobile laboratory
ICA-70 multichannel analyser /with 4K words memory/
TPA-CAMAC systems for process-control purposes as well as for automation of the measurements in nuclear, scientific, biomedical and general laboratories, and in industry and agriculture.

Up till 1977 more than 70 different module types were produced in the CAMAC system. Among them:

Controllers, intelligent crate controllers
Input/Output gates and registers
Analog modules, converters
Clock generators, timers
Display modules, peripheral interface
Test modules
Crates and power supplies
Other units in a permanently widening selection

Each fourth employee in the research centre is a highly qualified professional.

Apart from our academicians - the majority of the staff have some kind of higher degree /D.Sc., M.Sc., Ph.D., etc./.

KFKI considers the training of scientists, individual extension training and the employment of aspirants to Candidate's and doctor's degrees at home and abroad as a task of high priority.

In accordance with the Government's science policy and with the interest of the Academy of Sciences, KFKI supports the idea that research workers - after the expiration of their contract with the Institute - make good use of their scientific experience by working in industry, education in numerous other fields of the People's economy. Close links have been forged with a number of foreign partner institutes and this collaboration manifests itself in the study tours of visiting researchers. KFKI staff publish their results by delivering lectures at conferences at home and abroad and also in top-level journals.

By no means the least of its attributes is the fact that the research centre provides every opportunity to any member who their knowledge to wishes to put their knowledge to good use at the universities and at other institutes of higher education as part-time lecturers.

In this way science gets nearer to life and life to science.

The merits of computerized education

In secondary and high schools and in colleges throughout the world students are finding it necessary to learn and to cope with greater and greater amounts of material, they are learning it more thoroughly with the aid of computers. Computers are helping students to learn not only the facts, but also how to use these facts in a wholly contemporary and realistic manner.

Computers improve the scope and quality of education. The student must literally teach the computer to solve his problem and when he is working at the terminal, he is the master of the machine. The computer knows no biases; it is scrupulously fair and infinitely patient, and no matter how complex the problem, the computer is unfailingly accurate and lightning fast.

At the same time the computer, almost alone among educational innovations, is able to provide and sustain a high level of student interest, involvement and motivation.

In exploring a new concept with the computer, the student sets a challenge for himself, then rises to meet it - the perfect example of self-motivation.

Because students are learning concepts more quickly and eagerly with computers, teachers find they have more time to spend on individual student's problems. In addition, students spontaneously tend to work cooperatively in small groups and develop a real sense of comradeship.

Today, our lines and the frontiers of knowledge are changing at a rate unimaginable in the pre-computer age. The school computer is the key opening the way for all students to the background and motivation they need. It is the key to meeting the challenge of today's education.

What can the computer do in the classroom?

As a drill master, under the control of a previously prepared program, the computer will exercise the student in mathematical skills.

Drill and practice programs all have essentially the same basic format: a problem is presented, the student responds, and the response is compared with the expected response. If it is correct, he goes on to new material. If incorrect, he is given another chance. A further advantage is that, wrong answers can be analysed and a message printed telling the student what concepts he needs to review.

Tutorials may present material in a very straightforward manner or they may be problem-oriented, that is, aimed at helping students develop problem-solving or critical thinking skills through interaction with the computer.

Diagnostic and remedial programs may be incorporated in the tutorial so that, depending on student's responses, he may be branched to the appropriate sequence.

As a simulator - under the control of a previously prepared program, the computer will simulate real world situations, or theoretical or abstract models.

Interacting with a simulation program allows students to experience events that they might otherwise never be exposed to, such as landing a lunar module, studying the effects of pesticides on various types of insect life or taking part in an important historical event.

In other instances the computer simulates apparatus out of reach of most schools and laboratories, e.g. a linear accelerator, a cryogenic chamber, or an electron microscope. In fact, virtually any device or process can be simulated.

Some simulations compress time. For example, it is possible to study hundreds of generations of genetic mutations, or the life cycle of a river or lake or even of our own planet.

Simulation and games offer numerous advantages to the educator by comparison with other methods of instruction. By participating in a simulation or game, students develop an understanding of the dynamics of an event or system, and a respect for the complex interplay of variables. More important, they discover new concepts and principles, not passively by reading or simply by being told about them but by actual participation.

As a problem solver - not under the control of a previously prepared program - the computer may serve as a sophisticated tool to be programmed by the student as an exercise in algorithmic thinking.

Problem solving represents the most widely implemented instructional use of the computer today. In problem solving, the computer becomes a laboratory for testing and using mathematical methods and logical relationships, and it requires the student to analyse and organize a problem into logical steps. This problem organization is often presented in the form of a flowchart. A computer program is then written and tested. Using a computer, the student is continuously aware of his progress, hence he is motivated to correct his errors in order to achieve a fully operational program.

The computer is an ideal vehicle for this sort of exercise; and though it is infinitely patient it does tell the student when things are not right and performs eagerly when finally given a correct program. Once freed from a tedium of calculations, students become deeply involved with procedures and processes rather than results.

Description of TEASYS components and configurations

In the following pages we give a general description of the components used to build a TEASYS configuration. Beside the technical parameters the educational viewpoints are mentioned too, these are at least as important as the technical data.

The TEASYS consists of three main parts:

- physical elements /hardware components/
- program languages /software systems/
- educational program package /worked out solutions of teaching tasks/.

There exists a very strong interdependence between these parts. Hardware could determine the speed and limits of the system, software influences the type of solution of the educational tasks, and some problems of the teaching process demand special hardware components. Firstly hardware and software elements are discussed, a brief description of educational program package will be given in the next part.

Hardware components

The TPA-i minicomputer is the nucleus of the whole system. It is essentially a 12-bit machine, with 1 μsec cycle time, ensuring the proper speed and accuracy for an average educational problem. It can be built into an internationally accepted rack, or if enclosed within a metal cabinet it is called a table version. Its well designed engineering control panel makes the system's build up, servicing, and fault correction an easy job.

The main memory of the machine can be determined in modular manner. The basic module /8k 12-bit words/ is built into the main frame of the minicomputer and even with such a low capacity of direct access memory the simplest version of TEASYS is efficient.

Even so, a memory extension unit with the capability of 8k words is proposed for the full usage of the system's time-sharing capability.

The instruction set of the machine is highly comprehensive and more than two hundred different instructions are possible thereby ensuring economical and flexible machine level programming. And a very important feature, due to the instruction set: the TPA-i minicomputer is compatible at program level to the well known PDP-8 mini-machine manufactured by DEC /Digital Equipment Corporation, USA/. This means that programs written for the PDP-8 - with the highest number of applications in the world - can be run on the TPA-i computer without any modification. /The hardware details of the two constructions are quite different, the compatibility relates only to system parameters and program level./

The peripheral devices are the following:

The teletype serves as the main element of the educational configuration. It is sturdy, untemperamental, nearly foolproof, and needs very little attention. It can be used in stand-alone mode too, making program preparation possible. Though the teletype is not noiseless, and its speed is limited compared to printers, up till now it appears to have no rivals against its use in educational systems.

Displays based on cathode-ray tubes represent a very important means of teaching. In our educational set-up two types are available. The alphanumeric display presents only letters, numbers, and other special characters on its screen. It can be controlled through a keyboard quite similar to that of the teletype. As it is silent in use it is a very attractive educational medium. The raster-type quasi-graphic display, apart from the possibility of presenting alphanumeric characters, is able to display curves, and drawings. This highly valuable feature can be controlled by the computer or manually by means of the track-ball which causes a light spot to move to any position on the screen.

Consumer TV-sets can be connected to both types of display mentioned above, making possible the unlimited repetition of the pictures. So in an auditorium or in a large school-room easily visible pictures can be supplied at the most suitable places at a really moderate cost. These types of terminal, however, lack the feature known as interactivity.

The paper-tape reader and punch must be mentioned too. These devices coupled to the computer simplify program loading and development. These peripherals are not for students: generally they must be handled by the teacher.

A magnetic storage disc may also be involved in the systems. Such an item of equipment widens the scope of applications enabling the run of chained programs and the solution of complex tasks requiring large memory space. The capacity of the storage disc is 256k words.

The cheap, but reliable mosaic printer may serve very usefully in listing long programs, long texts. Its printing speed /appr. 60 lines/min/ can be exploited in different circumstances, for example, in grade evaluation, or in the school's administrative work.

The scope of the TPA-i educational configuration can be seen in the illustration on. The terminal devices form an essential part of the system from the educational viewpoint. The tape peripherals, disc, printer, etc. can be located elsewhere /perhaps even in another room/ isolated from the students.

The hardware devices have the following characteristics important is the field of education:

reliability - based on the proper selection of circuit and mechanical components

simple and clear control panels - facilitating handling by non-technical people

no special environmental considerations - normally even air conditioning is unnecessary

power-fail protection - makes possible the easy re-starting of the system after power troubles

simple check and maintenance - can prevent run-downs during critical periods.

Software components

The software background of the TPA-i minicomputer is extensive and increases year by year. Naturally we deal here only with the possibilities relating to the educational field.

The TEASYS is essentially BASIC oriented. BASIC was originally developed at Dartmouth College and it has since been made operational on many computers. BASIC's strength lies in its simplicity. Students can be set to work on their own with BASIC after as little as a few hours. BASIC is a "mansized" computer language: the machine poses questions and waits for the answers after which it sends written concerning the validity of the answers all in such a manner as if an untiring teacher were behind the computer cabinet.

There are different types of TEASYS, characterized primarily by the features of the software.

TEASYS-20 is based on a low cost, multi-user BASIC, which can serve up to eight terminals simultaneously. It can work in immediate /calculator/ mode of operation too, though it is mainly an interpreter translating well-formed instructions line by line and performing them immediately. This version of BASIC allows multiple statements per line and also processes alphanumeric strings. It has a very effective editing feature: modifications in a program line can be made without retyping the whole line. At the start of the work the system must be generated and the available memory capacity must be divided among the terminals in use. An easily understandable error diagnostic helps beginners very much. The TEASYS-20 can be shared among classes, departments or teachers disseminating computer methods and advantages throughout the whole educational establishment.

TEASYS-30 is a disc-based BASIC computer for one terminal containing all the advantegeous features of TEASYS-20, and in addition it can contain dozens of programs on the disc, so teachers are not required to manipulate with paper tapes. There is a priviliged program-saving possibility which helps to avoid confusion in the case of several users following each other. A program chaining possibility and a very powerful alphanumeric string handling capability complete the system. The printer connected to the configuration speeds up the work.

There are variants of both TEASYS-20 and TEASYS-30 /known as TEASYS-20/D, TEASYS-30/D/; the suffix D refers to the fact that these versions are able to drive a quasigraphic raster type display so that programs written and run in BASIC can be plotted directly on the screen controlled by special instructions handled by the computer.

Summarizing, we refer to Table 1. which presents the most important characteristics of the TEASYS configurations and software back-up. /Fig. 2./

Beside the above written software facilities there are other programming systems too which can be run on TEASYS configurations without difficulties. These are, in brief:

SLANG	- a powerful assembly level language for high efficiency programming
FOKAL	- BASIC-like program language, with raster display handling capability
FORTRAN	- a successful version of minimachine - FORTRAN
MINIBOL	- a COBOL-like language for economics,
	etc.

Brief description of BASIC /TEASYS-20/

The TEASYS-20 system is an up-to-date tool of computerized education. The main characteristics are the following:

- interactivity
- modularity of programs and program packages
- enforcement of pedagogic guiding principles to an increasing degree, in the architecture of the programs.

The system is operated by statements and commands. Line numbers stand before the statements and these are elements of the user's programs. The commands give orders to TEASYS system and they concern listing, running, correcting, deleting of programs and designation /allocation/ of peripherals. The statements contain arithmetic operators, relational operators and key words. The key words are fundamental words which are abbreviations of English words referring to the essence of statements. These key words can be assignments, control and input-output statements.

The operands can be constants, variables, strings and functions. There are two types of functions:

- standard functions
- user-defined functions.

Why does the BASIC-TEASYS lend itself particularly well to education?

1. The system is easy to learn. It is quite simple to write a new program or to complete existing programs. For this reason individual pedagogic conceptions can easily, without effort, be built into the system.

2. The strings and the simple handling of strings in the BASIC promòte the placement of explanation texts and questions in the programs without special program tricks.

3. The TEASYS system contains some purpose-made functions for education besides the conventional standard functions.

Scope of the teaching program package

The teaching program packages are always developed with a view to helping to shape creative way of thinking. The introductory questions of program packages therefore control the knowledge of principles and relationships /meaning the sum and substance of the subject/ and computation and solution of examples and the drill of knowledge will be taken in their turn only after this.

All program packages are suitable for use with the computer but, in addition, they are suitable for use with other devices /programmed, manual, head projector, slide projector, tape recorder, etc./ too. Though the string-handling of BASIC is quick and simple, it would, after all, be an exaggeration to engage a major part of memory and computer time with writing and texts. A wide range of devices promotes the possibility of getting acquainted with the subject - matter making it easy to survey but, at the same time, losing no detail whatsoever.

The frame programs determining the connection and modularity of programs can be linear or branching. In the case of linear frame programs all students work out the same questions in the same order. The branching frame programs give the next task depending from the last answers. The branching frame program is much more suitable for individual learning than the linear one because the branching one takes much more into consideration: when the student is slow in understanding, when his fundamental knowledge is insufficient, or he wishes to deal with the subject matter more profoundly.

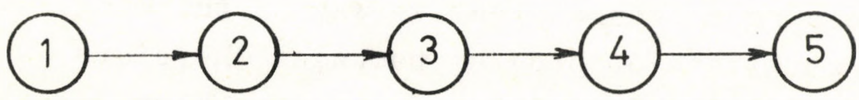

Fig. 1a. Linear frame program

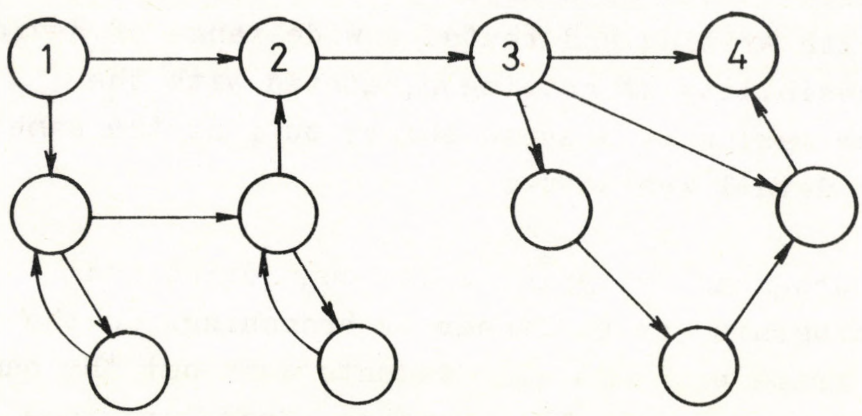

Fig. 1b. Branching frame program

Fig. 1.

Mathematics

The mathematical program packages help three age-groups to learn and to practise mathematical skills. These groups are:

- pupils in the primary school
- students in the secondary school
- teachers and instructors in technical/scientific field.

The program package for primary schools consists of two parts. The first part sets as an aim the shaping of the number concept, the practice of operations and the establishment of further mathematical learning. The second part consists of games, which help to develop entertainingly, a logical way of thinking and thus, the mathematical ability of the children.

The program package for secondary schools contains the main principles of algebra, trigonometry and function theory. First the knowledge of fundamentals is controlled by the system in each topic, then appropriate examples are provided while, at the same time, the sequence involved in the solution to the problem is outlined. Only after these steps are tasks given, with the correctness of solution being controlled by the computer. The packages have a built in checking system which is combined with error-statistics made by the evaluation of pupil's various mistakes.

The principal merit of TEASYS is, the benefit it offers in relation to refresher courses and to post-graduate education. In addition these program packages provide a good opportunity to learn programming too. The program packages for post-graduate education come in two arrangements:

the first package is constructed for individual learning, the second one provides for education in groups.

The common characteristic of all program packages is not merely that the mechanical acquiring of subject-matter and the relevant automatic drill are made known, but that an understanding and an adoption of the main ideas are ensured.

Social sciences

The computerized education of social sciences has two aims:

- the drill of lexical knowledge
- the understanding of main lines of thought, and important principles.

The "football-pool" program is a good foundation for lexical knowledge. Such a program consists of three choices and the students must select the appropriate one. In another useful program package three items of data that belong together have to be picked out from 3 x 12 data /e.g. name of a country, name and height of a mountain/; this program package is a useful tool in relation analysis.

Dynamic models ensure the understanding of main lines of thought and important principles. The models are produced by simulation and the student has the possibility to choose the value of the various parameters. The relationship between the parameters and the process can be observed in a simple and easily understandable way.

	Number of users /max/	Memory /min/	Disc	Special feature
TEASYS-20	8	16k	-	-
TEASYS-20/D	1	16k	-	Quasigraphic display
TEASYS-30	1	8k	1	-
TEASYS-30/D	1	8k	1	Quasigraphic display

Table 1.

For the teacher:

Tape peripherals:

Reader
Punch

TPA-i
central processor —— Disc

Teletype   Alphanumeric displays   Quasigraphic displays

TV sets

For the students

Fig. 2.

Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Sándory Mihály
Nyelvi lektor: Harvey Shenker
Példányszám: 220 Törzsszám: 1977-911
Készült a KFKI sokszorosító üzemében
Budapest, 1977. szeptember hó