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Microcomputer Didactic Programs in the Teaching of Technical Subjects

1. Introduction

The theory and practice of constructing working programs[1] is now universally widespread. The aim of such programs is to enable the trained operators to solve concrete tasks quickly and cheaply. As a rule, working programs are not suitable for educational purposes , i.e. for acquisition of a definite amount of knowledge, for teaching how to solve concrete tasks, or design engineering processes, buildings, machines and installations. The term working programs is used to distinguish them from didactic programs designed for teaching purposes.

Didactic programs for the teaching of technical subjects use mainly graphic illustration and analytic description, and verbal description is used in a small degree for transmission of information. On the other hand, didactic programs for the teaching of humanities are based mainly on an ability of editing texts.

Construction of a good didactic microcomputer program seems to be a more difficult, more complex, and more time-consuming task than construction of working computational programs which also include scientific programs. It is particularly difficult to construct programs which could be used in the teaching of technical subjects, and it is especially difficult to construct programs for teaching of designing objects, machines, and installations, because of a great number of optimization parameters, and because input and output data are represented graphically, by mathematical formulae, numbers, and text.

One of the reasons of the acute lack of educational programs on the academic and school market almost all over the world is a lack of sponsors who can finance teams of specialists capable of constructing didactic programs - due to high costs of constructing such programs.

In the present paper an attempt is made to analyse and formulate principles of construction of didactic programs.

1) *In a group of professional computer programs devised by specialist teams and amateur programs constructed for individual use, one can distinguish working programs, didactic programs and computer games.*

2. Analysis of needs in computer aided didactic forms used in higher technical schools

In engineering didactics, we can distinguish the following historically shaped forms of teaching engineering subjects : 1) lectures embracing synthesis of a subject improved every year ; 2) design classes embracing the teaching of designing structural systems ; 3) computation classes which illustrate solution of major problems described by mathematical algorithms ; 4) laboratory classes which deal with handling and processing of measurement results ; 5) seminars concerned with a detailed analysis of selected problems. Each of these didactic forms requires a different approach during realization of computer programs.

Computer programs used during lectures should take into account individual features and needs of lecturers. Then a lecturer should have at his disposal a problem-oriented language provided with basic animated macroinstructions , and basic computational blocks . The lecturer will then constructs illustration to his lectures from such blocks - in the same way as he used structural solutions (drawings) or anlytical algorithms from autopsy or available literature. Students should have access to the particular animated instructions during repetitory work.

Design classes are and will be the main field of the application of microcomputers to the teaching of engineering subjects. At present microcomputers are used in such subjects as mechanics of building structures or electrical systems, i.e. in problems involving complex, - especially matrix - arithmetic operations. Currently above all working programs transferred from standard programs of design offices are being used. A few attempts made so far to introduce specialized, didactic computer programs can be treated in most cases as attempts at improving the working versions. In the further part of this paper, we shall present a packet of didactic programs in which some programs are also the improved working versions. However,these improved working programs concern marginal problems which are included in the framework of other subjects, and improvement has been achieved by introducing numerous graphic illustrations.

Computation classes require computer programs which have common features with programs used during lectures and design classes. The basic aim of those programs is to get students acquainted with the mathematical description of physical phenomena occuring inside systems, structures, or engineering processes.

Laboratory classes are most frequently connected with experimental ivestigations of structural elements or elements of physical processes, and they provide students with a number of measurement results. Application of microcomputers during laboratory classes can be aimed at using microcomputers as measuring devices or using them as tools for statistical handling of processed or direct results of measurements, or as an aid in the interpretation of results.

Selected didactic and working microcomputer programs as well as special programs suited for solving nonconventional problems can be used during seminars, repetitions and diploma seminars.

Description and knowledge transmission to students in engineering require application of: 1) graphical illustration of structures, technology and performance of objects and installations (this makes even up to 90 per cent of techniques of description); 2) mathematical illustration and mathematical determination of structure parameters, process engineering and operation (ca 5 per cent or more depending on a discipline); 3) descriptive illustration or text editing (ca 5 per cent).

3. Analysis of application of a packet of didactic microcomputer programs

In order to draw conclusions concerning the principles of constructing didactic programs, an analysis was made of the application of a packet of microcomputer programs CONSTUCTOR1 [1]. This packet was developed at the Faculty of Civil Engineering,the Technological University of Kielce, in order to assist design classes of metal building structures. The packet includes programs WINCLER, BEAM1, TRUSS2, FRAME, PLATGIRD, STABIL, BOLT, BAR, CRANE.

Programs WINCLER, BEAM1, TRUSS2, FRAME were developed essentially to reduce stability computations of cross-sectional forces and displacements in continuous beams with constant and variable stiffness, in flat and spatial truss rods, and also float frame rods. These programs have the characteristics of working programs, suplemented by animation effects, and possibilities of dialogue computations. While making use of these programs students have a chance to consolidate their knowledge acquired previously when they took a course in Theory of Structures.

The other programs in the packet CONSTRUCTOR1 concern strength calculations and designing elements of metal structures: designing of plate girder continuous beam cross-sections along the beam length (PLATGIRD), testing local stability of webs of welded girders (STABIL), testing strengths of frontal high tensile bearing-type bolt joints, and joints with common screws (BOLT), designing of multi-branched compressed rods (BAR), and designing of crane beams (CRANE). These programs make use in great degree of the graphic capacity of the microcomputer graphic monitor adapter. An attempt was made to include elements of game maximal availability of dialogue calculations. An iterative calculation approach was employed instead of algorithms of automatic optimization. Extended program handling of both synthatic (wrong key or keys) or substantial (wrong parameters introduced by the student) errors. This programs allowed to construct wholly closed "intelligent" programs resistant to errors, with a number of instructions and comments.

4. Principles of construction of didactic programs

It follows from an analysis of the needs of computer aided didactic forms and conclusions derived from the application of the constantly improved packet of programs for the teaching of metal structures [1] that varied range of microcomputer use is feasible during classes: from pure didactic programs to working programs adding the teaching process. It is to be noted that such differentiation of microcomputer application should agree with a particular didactic form ; and therefore, purely didactic programs should be used at all types of classes - especially during lectures and computation classes - whereas working programs should be used in laboratory and design classes as well as seminars which review topis taught previously.

Fig. 1a shows the basic elements of didactic microcomputer programs, and beside, in Fig.1b - the basic elements of working programs.

Graphic illustration , which is indispensable in didactic programs, has the following objectives: 1) to illustrate the physical sense of phenomena and processes occuring in the mathematical model of a structure or egineering process ; 2) to present the principles of correct formation of structural elements and systems ; 3) to illustrate calculations.

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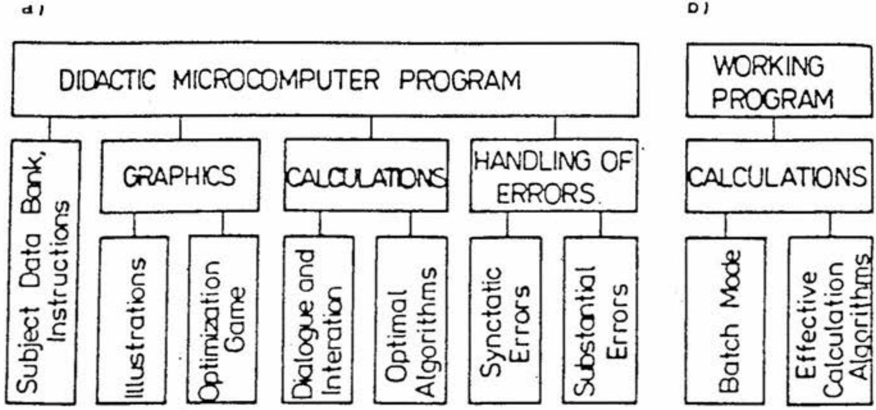

Fig. 1 . Basic elements of microcomputer programs : a) didactic, b) working

Didactic programs should combine elements of advanced calculation methods with elements of computer games.

Calculation algorithms to be used in didactic programs should enable one to carry out dialogue exercises. Iterative algorithms used in place of algorithms of mathematical optimization are suitable for dialogue calculations. In the iterative process students can be taught, in an easy and simple way, designing which takes into account multitude of parameters. In order to be able to make many iteration cycles, optimal numerical algorithms should be used as soon as possible.

Didactic programs should have extended handling of substantial and syntactic errors. A limited confidence in the user should be considered as a principle. It may be assumed that the user-student is able to makemost exotic errors. Instructions, comments, and warnings shown on a separate part of monitor should be an essential part of a didactic program. At the same time it is necessary to construct separate blocks with instructions which can be shown at the student's request.

At present microcomputers seem to fulfill almost all needs of didactics. It is advisable to develop professional didactic programs in languages that allow to transfer procedures to other types of microcomputers. Now most programs written in C language meet these demands.

5. Concluding remarks

A high demand for didactic microcomputer programs for the teaching of technical subjects can be satisfied by specialist software firms, and only in part by educators producing programs for their needs.

Construction of didactic programs should take into account different didactic forms: i.e. lectures, classes, and seminars.

A didactic program for the teaching of technical subjects should fulfill the following conditions :

1) to have an expert data bank related to a particular course ;
2) to be realiable, i.e. suitable for tasks carried out by working programs ;
3) to change work into game ;
4) to allow a dialogue and iterative mode of calculations particularly at moments of predicted knowledge thresholds ;
5) working procedures to be used in didactic programs should be optimal, i.e. they must be accomplished in shortest possible time ;
6) the program should be resistant to syntactic and substantial errors;
7) a didactic program should have extensive handling of substantial errors. It should signal wrong decisions and communicate necessary changes ;
8) simple review and comparison of solution variants should be allowed;
9) output data and results of numerical decisions should be illustrated graphically in a way enabling one to understand the physical sense of investigated problems, processes, or phenomena ;
10) every time a didactic program should enable one to make use of instructions, comments, and graphical linguistic or numerical warnings.

A general conclusion can be drawn from the so far experience of the theory and practice of constructing didactic programs : provision of lectures with didactic programs allowing to take into account the individual features of lecturers will result in a qualitative change in the traditional division of teaching units into lectures, classes, design, labs and seminars.

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