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# Unification of Computer Support for Academic Disciplines to Increase the Prestige of the University and to Reduce the Effects of Mass Self-Isolation

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***Abstract*—The advisability of a unified computer support system for academic disciplines with high scientific content, included in the study program for specialists in ordinary universities of a technical profile, is discussed. The reasons for the lack of prestige of ordinary universities are analyzed and areas of research to increase prestige are listed. The article provides information on the difficulties of the urgent transition to mass distance education with the self-isolation of ordinary university students during epidemics such as COVID-19. The authors emphasize the positive influence of computer support unification on increasing the prestige of education in ordinary universities as well as on reducing the shock effects of mass self-isolation. Computer Algebra System Scilab is proposed as a platform for unified computer support. An illustrative example is included.**

***Keywords—ordinary university, higher educational quality, unified computer support, disciplines with high scientific content, mass self-isolation, Scilab***

## I. INTRODUCTION

Paradoxically, the pandemic of COVID-19 as a global disaster had stimulated positive changes in the technology of distance teaching methods in universities. These changes were caused due to the urgent mobilization of the entire lecturers' staff to develop the teaching methods in the conditions of self-isolation both of students and teachers themselves. Perhaps the experience of universities in a pandemic of COVID-19 would lead to revolutionary changes in education technology increasing the individual component of teaching. Such experience needs to be systematized and generalized.

 

The presented work as the part of this common problem is directed to achieve two correlated goals: firstly, to increase the prestige of education in ordinary (local) universities of a technical profile, and, secondly, to reduce the influence of the shock effects of the forced transition to mass distance education in conditions of rigid self-isolation. A single means for the partial achievement of both goals are proposed – unification of computer support for the study of disciplines of natural science and engineering.

The article is structured as follows:

1) The usefulness of unified computer support of teaching disciplines for increasing the prestige of education in ordinary (local) universities of a technical profile.

2) The application of unified computer support in a laboratory and practical works in the conditions of mass distance education accompanied by self-isolation of students and teachers because of emergencies (pandemics, natural disasters).

3) Description of the unified support system platform (computer algebra system Scilab) and example of its application in one of the laboratory works.

## II. On the Teaching Study Problems in Ordinaty Universities

As the basic method of the research was defined group Significant differences in the school successes of university entrants of ordinary and leading universities as well as in scientific schools of the teaching staff, lead to crisis phenomena, in many cases threatening to the very existence of the ordinary university. These phenomena lead to a decrease in university entrants' number and simultaneously to receive the entrants with worse school preparation.

It would seem that the way out of the crisis is small university closure. But this measure is unacceptable because it can lead to a deepening of the province intellectual degradation which intensifies the extremely dangerous phenomena of small and medium-sized cities depopulation [1].

One of the arguments justifying the introduction of the Unified State Exam (USE) was the equal conditions to receive a prestigious higher education. Such equal rights were postulated for all graduates of secondary schools in the country. There is no doubt that the USE is useful as a single measure of the quality of school preparation, free from the influence of localism and bias. But for medium-sized and small cities, the introduction of the Unified State Exam has led to losses of best school graduates as city habitants. They prefer to receive higher education in prestigious universities of megalopolises and rarely return to their city. Therefore the high quality of their knowledge which they will receive at the leading universities doesn't lead to the increase of small city specialists' average qualification.

Therefore the only way to receive engineering personnel for industrial enterprises of medium and small cities is to teach them at a local (ordinary) university. But due to the outflow of the best secondary school graduates to the universities of megalopolises, the school knowledge level of local university entrants is often insufficient to perceive study programs comparable with the theoretic and scientific foundation of study programs in leading universities. As a result, graduates of a local technical university, working at enterprises in their city, only rarely use the achievements of simulation, optimization, control theory, and decision-making methods in their industrial activity, without which it will not be possible to overcome the technical backwardness of the province. We can say hyperbolically that there exist two technical civilizations in the country: one (corresponding to the world level) - in the spheres of science, design, and production in megalopolises, and the second (lagging behind the world level for decades) - in the production sphere of the province. This situation is dangerous to the country as a whole.

Analysis of the dynamics of changes in the average USE score carried out for one of the typical ordinary technical universities (Kamyshin Technological Institute (branch) of the Volgograd State Technological University) showed that over the previous 10 years the average ball has decreased from 60 to 48 points (Fig. 1) while the average USE score of entrants of leading universities is at least 80 [2].

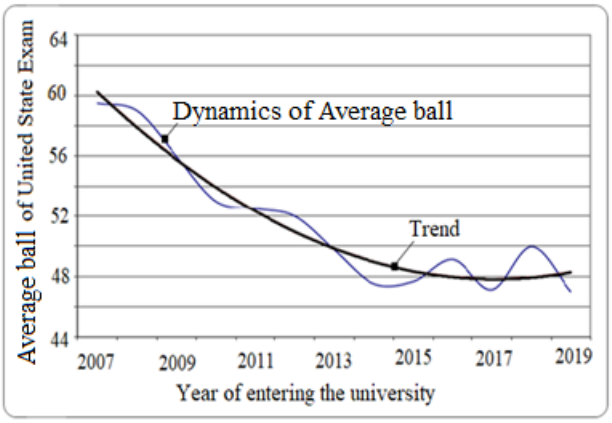


Fig. 1. Dynamics of USE average ball

The above considerations show the actuality and complexity of the problem of raising the prestige of education obtaining an ordinary university. The solution to this problem should raise the attractiveness of ordinary universities for entrants leading to the tightening of competitive conditions for university admission and (as a consequence) to the possibility of teaching the academic disciplines on a modern scientific platform.

## III. On Researches Directed to Increase the Prestige of Education in Ordinary Universities

An analysis of the problems of education in ordinary universities showed that it is necessary to search for a set of measures directed to ordinary universities attractiveness. Such measures, on the one hand, would interest well-trained school graduates in choosing a local ordinary university for higher education. On the other hand, such measures would compensate the insufficient school preparation of entrants with a low grade of Unified State Exam. To find the way for this problem solving, during the last several years the research

groups of Kamyshin Technological Institute are carrying out the investigations in the following areas:

1) The estimation of the entrant's expected successes of the university program study based on the indicators of school performance. The application of this estimate for the entrant's advising on the choice of study direction with good perspectives of his successful future study in the university [3].

2) Clustering of natural sciences and engineering disciplines studied at the university and on its basis the formation of cyclograms of disciplines essential for various types of university graduate's future professional activities (production activities, scientific work, design, teaching, etc.) [4].

3) Clustering a student group into subgroups with a homogeneous preference for clusters of natural science and engineering disciplines.

4) Individualization of tasks for laboratory and practical works depending on the results of a student group clustering.

In addition to the measures mentioned above, we are proposing the facilities directed to freeing up the part of the study time for teaching the disciplines with deep theoretical filling through the introduction of a unified system of their computer support. This part of the study time may be useful by strong students – to develop their creative capacitances through participation in the scientific work of university faculties and to self-education, while for poorly performing students - to additional classes on theoretical foundations and methods.

Teaching the basics of the proposed unified system as part of the discipline "Informatics" (1st semester) will eliminate the need for duplication of this teaching at proceeding courses and will allow us to focus only on substantive issues.

Further we analyze the possibility of such a unified system application for the cyclogram of academic disciplines with deep scientific filling. For example, we consider below the cyclogram of such disciplines included in the study program for bachelors of the "Computer Science and Computer techniques" direction, namely: computational mathematics - simulation - control theory - experimental data processing - optimization methods - decision-making theory.

## IV. On the difficulties of distance teaching students of technical profile

The pandemic of COVID-19 has led to the need to urgently developing of effective methods of distance education in conditions of students' and teachers' mass self-isolation. Some specialists (especially humanitarian) disbelieve in the effectiveness of mass distance education, hoping for the uniqueness of the epidemiological situation in 2020. This position is disputable concerning technical specialties study. The decrease in the effectiveness of distance lectures carrying out (in comparison with usual manner) can be compensated for by greater independence in distant fulfillment of laboratory and practical works using virtual models of real processes.

The general purpose of laboratory and practical works is to teach students the complex process of transition from the problem statement formulated on a natural language, to its solution based on strict formalization and simulation. Currently, the computer support for the disciplines of the cyclogram is, as a rule, heterogeneous (especially in ordinary universities). For example, the different systems of Computer Algebra Systems (CAS) are widely used: spreadsheets, CAS Mathcad, less often - the most powerful CAS for engineering computation Matlab. The heterogeneity of computer support in the traditional teaching system does not affect the teaching process since these facilities are embedded in the software of computer classes and are therefore available to each student. But in conditions of mass self-isolation, the availability of heterogeneous computer support for students' home computers is practically excluded by the high cost of corresponding licensed software.

Hence, it is necessary to choose the computer support tools with applicability not only in the traditional teaching system but also in the distant teaching, including extraordinary situations (in particular, in self-isolation of students and teachers during epidemics). Therefore the requirements to such choice are following: (1) unified computer facilities should be sufficient for supporting all disciplines of cyclogram; (2) the possibilities of unified computer support should be sufficient for implementation of all algorithms and computational procedures studied in each discipline of cyclogram; (3) computer support facilities should be available to self-isolated students.

The best solution that meets requirements 1 and 2 is CAS Matlab with Simulink visual modeling tools. Unfortunately, this CAS does not meet requirement 3, since the high cost and resource intensity of the product practically exclude its use on students' home computers.

## V. On the possibilities of CAS Scilab application

CAS Scilab [5] was historically created as an open free cross-platform system, whose functions largely coincide with the commercial CAS Matlab-Simulink. We propose it as a perspective variant for the implementation of unified computer support facilities for academic disciplines teaching in ordinary universities. By now, successful experience has been accumulated in using Scilab for computer support of individual disciplines [6-10], but it was necessary to check whether Scilab tools were sufficient to cover all elements of computer support for each of the cyclogram disciplines. Without pretending to be general, we restrict ourselves to the analysis of the Scilab sufficiency for the cyclogram of disciplines with a deep theoretical filling which is included in the study program of bachelors of the direction “Computer Science and Computer Techniques”. The results of the analysis of Scilab tools to support each discipline of cyclogram are follows:

**"Computational Mathematics"**: linear algebra and matrix operations (including operations with sparse matrices); discrete mathematics and factorization; a library of special functions; numerical differentiation (discrete derivatives, gradient estimation); integration (one-dimensional and

multiple integrals, integration of experimental dependences); solution of ordinary linear and nonlinear differential equations as well as partial differential equations.

**"Mathematical simulation"**: a powerful tool for visual simulation of dynamic systems; graphic support and processing of simulation results; typical models of dynamic processes; a library of generators of random processes; interpolation means.

**"Control theory"**: one-dimensional and multidimensional systems, discrete and continuous systems; controllability, observability, and identifiability of the systems; transfer function facilities and transformation of systems' structures; typical control laws; research of linear time-invariant systems using frequency responses and Bode diagrams; identification; Kalman-Bucy filters; deterministic and stochastic optimal systems; H-infinite systems.

**"Experimental data processing"**: descriptive statistics; a library of distribution laws of experimental data; processing data with abnormal values and gaps; estimates of data probability distributions laws; procedures for statistical check of hypotheses; experimental data filtering and smoothing; cluster and factor analysis.

**"Optimization methods"**: minimization of nonlinear criteria; nonlinear programming; nonlinear least-squares method; simplex linear programming algorithm; a library of genetic algorithms; semi-definite and quadratic programming.

**"Decision-making theory"**: events generator and processing; logical functions and logic algebra; operations with sets; examples of the application of optimization methods, statistics, and experimental data processing in decision-making problems.

Comparison of the methods implemented in Scilab with the study programs of the listed disciplines showed that Scilab tools cover not only all the issues included in the programs which require computer support but also leave students the opportunity for self-development. An additional advantage of Scilab is its similarity to working in the Matlab environment. Therefore university graduates will easily learn to use Matlab if it should be necessary for their successful activities.

## VI. Example pf laboratory work implementation in Scilab environment

The following illustrates the Scilab facilities application in the research laboratory work "Simulation of a greenhouse microclimate control system". In the work's proceeding, students learn the techniques of dividing functions between the researcher (determining the purpose of the control system and developing mathematical model, carrying out computational experiments and generalizing their results) and Scilab tools (implementation the model and preliminary processing of computational experiments results). The control system contains 2 circuits (temperature and humidity control, respectively), interacting with each other through cross-links (Fig. 2). A proportional-integral controller (PI) is used in each circuit. $W_{ij}(s)$ - are the transfer functions of the model channels, $i, j = 1,2$; $s$ is Laplace operator.

In the first part of the work, students learn the techniques of visual simulation using blocks of transfer functions, directly according to the block diagram in Fig. 2. Further, a more universal technique for multidimensional systems simulation in the state space is studied.

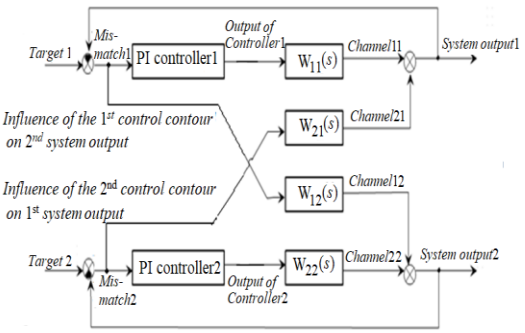


Fig. 2. Block-diagram of control system

In this case, the description of a linear time-invariant system with continuous-time t has the form of a system of the 1st order differential equations which is written in matrix form as follows.

$$\frac{dx}{dt} = A \cdot x(t) + B \cdot u(t), \quad y(t) = C \cdot x(t) + D \cdot u(t)$$

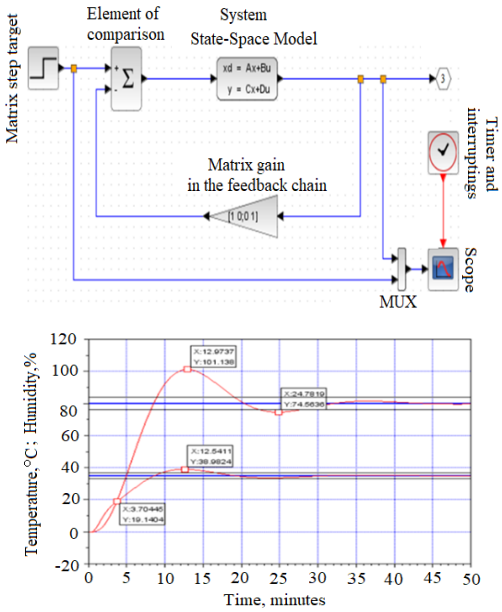


Fig. 3. Top: Scilab matrix blocks for state-space model. Bottom: graph support of simulation

Notations: $x$ $(t)$ is an $n$-dimensional state vector (its elements are all internal variables used to describe the dynamics of the system), $y$ $(t)$ is an $m$-dimensional observation vector (system output), $u$ $(t)$ is an $r$-dimensional vector of external influences (input). State vector components are state-space coordinates. $A$, $B$, $C$, $D$ are matrices, respectively, of dimensions $n \times n$, $n \times r$, $m \times n$, $m \times r$. The system of differential equations for $x$ $(t)$ determines the dynamics of

changes in the state vector of the system, and the algebraic system of equations for $y$ ($t$) correlates the output of the system with these changes.

## VII. CONCLUSION

1) The analysis of the problem of ensuring a high quality of education in ordinary universities is presented.

2) The unification of computer support facilities for all disciplines with a deep scientific filling, which are included in the study programs for teaching the students of engineering profile, is proposed.

3) The possibility of unified computer support tools implementation on the CAS Scilab platform, applicable in the traditional teaching system as well as in emergency conditions of mass self-isolation of students and teachers in epidemics and natural disasters, is discussed.

4) An illustrative example of Scilab application in a laboratory work studying the multidimensional system controlling is given.

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