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E-COURSE OF THEORETICAL MECHANICS⁵

Elena Ponomaryova, Tatiana Nevenchannaya, Vladimir Pavlovsky

Abstract: *The concept, structure and contents of the Internet textbook on classical mechanics intended for Higher Technical Institutions are presented in this work. Aspects of program realization of textbook applications and the technology of elaborating the textbook in the "Hecadem" Internet-teaching environment are given too.*

Keywords: *distant education, electronic textbook, Internet, mechanism.*

Introduction

The achievements in the field of information technology help to work out and use computer learning systems (CLS) in the course of teaching process, aimed at performing various types of teaching activity. The main principles of new CLS are the following:

- interactiveness;
- dynamics;
- integrativeness (program compatibility with other products);
- Web-compatibility;
- work providing in the off-line mode and distance mode;
- updating, replenishing with new material by subject teachers;
- modeling and simulation of examined processes and phenomena;
- visualization of educational information;
- illustration by sound aids;
- various services;
- control of knowledge with error diagnostics and feedback.

CLS is a more advanced means as it not only intensify non-textual parts (graphics, animation, video, sound) and various services, as well as, wide opportunities of Internet network.

Such systems we will name hereinafter as distance teaching systems (DTS). Now we consider the most common opportunities of DTS (Fig.1).

The first type (semantic elements): helps to study theoretical material of a subject, consolidate the knowledge of the material covered by solving problems and performing calculations, carrying out computer experiments and

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exercising intermediate and final knowledge control. These options bring closer DTS and traditional teaching process.

The second type (multimedia options): includes illustration of teaching material with the help of video and sound, animation and graphics as it helps to improve presentation of teaching material and arouse interest for learning.

The third type (interface, services): it includes options of creation of multilevel menu system, multiple window interface, system of hypertext jumps, text look-up. It helps to avoid laborious calculations and it accelerates the process of solving tasks as well as it helps to motivate learners for study and to liven up the work.

The fourth type (Web options): it helps to provide interactive link of a learner and a teacher through Internet (from primitive E-mail to the formation of off-line or on-line conferences), it provides searching of scientific and educational information in Internet and it helps to use references, etc.

Astrakhan State Technical University together with M.V. Keldysh Institute of Applied Mathematics of Russian Academy of Sciences developed technologies of creation computer distance/local learning system and so DTS on theoretical mechanics was created for this purpose [Pavlovsky, 2003], [Nevenchannaya T.O., 2003].

Computerization learning is of great independent and interdisciplinary importance in the field of theoretical mechanics as this subject is the basis for learning general engineering subjects and special courses as it teaches to highlight the modals for solving formulated problems, to lay down conditions, to solve problems, to determine the limits of their acceptability.

Developed teaching system includes the following parts:

- organization and information block;
- electronic Internet-textbook on theoretical mechanics (certificate on official registration of computer program №2004612620, Rospatent);
- manual aid "Theoretical mechanics on computer".

Let us consider each part in detail.

1) Organization and information block.

Organization and information block includes: course curriculum with indication of subject list and date of their performing; schedule of laboratory works, seminars and classes; syllabuses; programs; teaching charts; problem exercises; manual aid on theoretical mechanics.

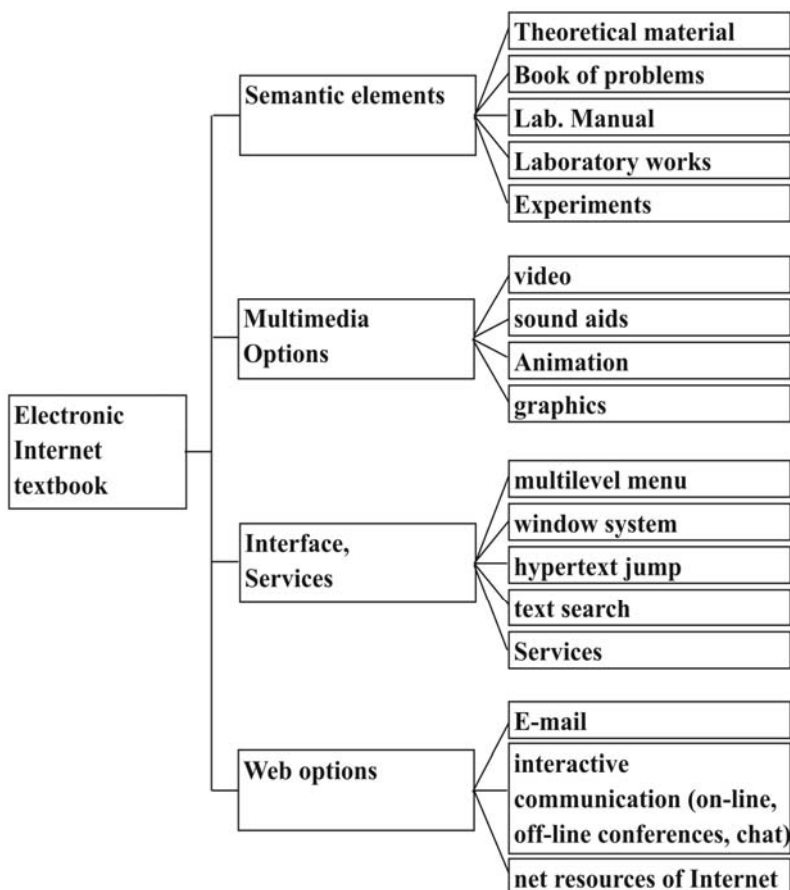


Fig 1. DTS possibilities

2) CLS on theoretical mechanics.

Let us illustrate the designed textbook (see [1-3] as well) and for its illustration we include the proposed technologies of creation DTS. They are based on the technology and host system of differentiable Internet training "Hecadem" in distance version [4]. Pattern of electronic Internet-textbook is illustrated in fig. 2.

Two versions of textbook were worked out; local and distance ones. These two versions of electronic textbooks were designed in shareable formats and they are Web standards.

Distance version of the textbook assumes the work by global information Internet and it supplies distance development of the textbook in Internet; creation of general array of knowledge elements on mechanics; formation of new teaching courses on mechanics type on the base of created array of knowledge.

Local version of the textbook is designed for work at autonomy device or in local network.

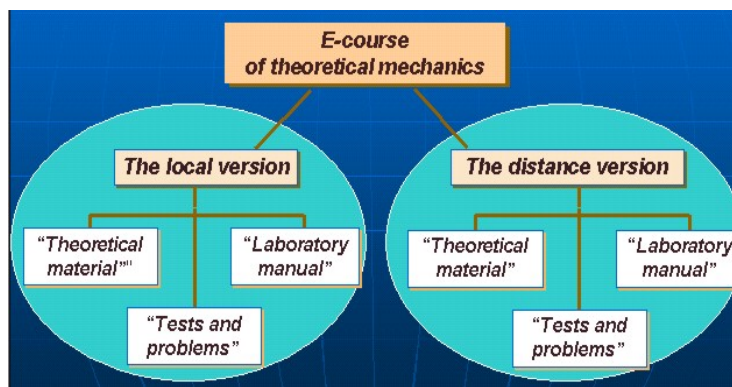


Fig. 2. Textbook pattern

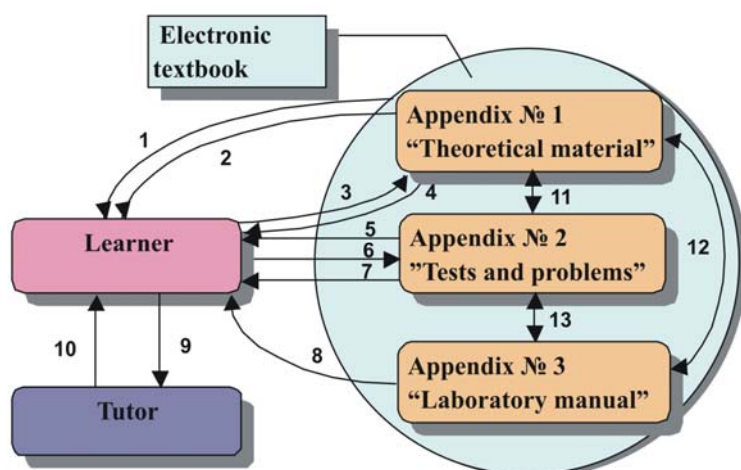


Fig. 3. Scheme of interconnections of a learner and electronic textbook

Each version of the textbook includes program appendix:

- "Theoretical material",
- "Tests and problems",
- "Laboratory manual" (fig. 3).

When working with appendix № 1 a learner is offered to study theoretical material (1), including the main definitions, theories, illustrations for worked standard problems. Each section has been studied, the learner answers the questions (self-evaluation) (2).

Fed answers (3) are transmitted back to appendix № 1, which returns the result to the learner after answers being analyzed (4).

When applying to appendix №2 a learner is offered a set of tests and problems (5), and he/she enters the result of a solved problem (6), then it is carried to appendix №2. The answers are analyzed by the appendix and then the result is reported (7).

The interaction of a learner and appendix № 3 assumes the participation of a tutor and it is reduced to the following steps: the appendix offers a learner design basis and calculated and graphical work (8). The work being done; the learner passes it to the tutor (9). The tutor evaluates the correctness of work, then the learner is informed the result (10).

Let us consider these appendices.

Appendix "Theoretical material" contains the theory of studied subject with the examples of solved standard problems. The appendix is performed in the form of two realizations: realization № 1, or "Course of lectures" where theoretical material is presented in a logical order as in a typical textbook; realization № 2, or "reference-précis", structured according to semantic elements. Hyper textual references help to work on this reference material.

Theoretical material of the textbook is presented in the following parts: "Kinematics", "Statics", "Point dynamics", "Dynamics of a system", "Analytical mechanics", "Calculation of mechanisms".

The first five sections are included into traditional course on theoretical mechanics. Section "Calculation of mechanisms" is also put into the textbook. The textbook is an original authors' teaching aid, the main concepts of mechanics being presented here as well as intersubject approach to the calculation of mechanisms and it helps to use knowledge from different fields for solving the problems [Nevenchannaya T.O., 2003].

Concepts of composing kinematical design on machine engineering drawing are presented here (fig. 4).

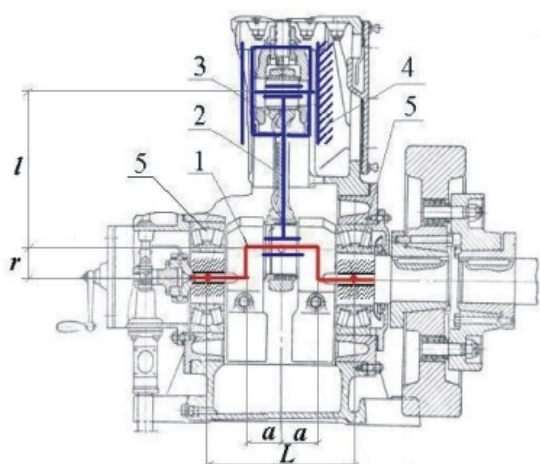


Fig. 4. Machine engineering drawing

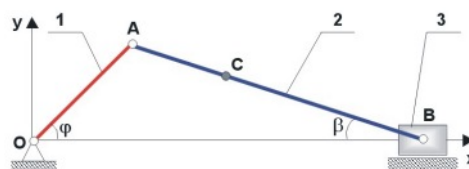


Fig. 5. Kinematical design

Link OA – crank - executes rotary movements.

Link AB – coupler - connecting rod-moves plane parallel.

Link B – slider - reciprocating along the horizontal guide.

Point O with coordinates (0; 0) is stationary.

Execution of crank-slider mechanism in the form of a rod and in the form of a circular links are examined in the kinematical circuit design (Fig. 6).



Fig. 6

Presentation of theoretical material is illustrated by a number of Web pictures, including animated illustrations 2D-, 3D-models of mechanical objects, mechanisms in particular (Fig. 7). Animated models of mate mechanisms, ellipsograph, scotch-yoke mechanism, and link gears with swinging and rotary link, planetary gears with inner and outer catching and many others are worked out and used now.

The models illustrate total cycle of mechanism movement, they are parametric and complicated.

Development of each model is rather labour-consuming process. Let us discuss the technology of producing 2D-, 3D-animated models of mechanisms in more detail.

A) Creation of computer animated models in mathematic packing MAPLE.

Options of MAPLE in the field of development animated graphics help to create 2D-, 3D-animated models of real mechanisms and to deduce graphical plots of parameters to time.

Sequence of operations for production of animated model in the environment of mathematical packing MAPLE is presented in Fig. 8.

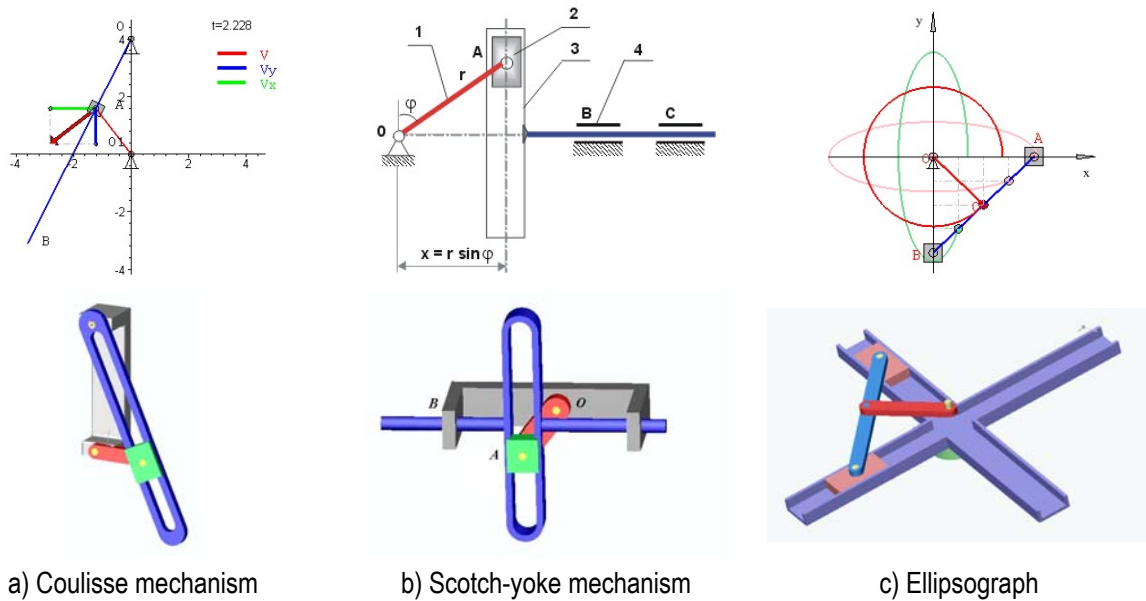


Fig. 7. Models of mechanisms (illustrations)

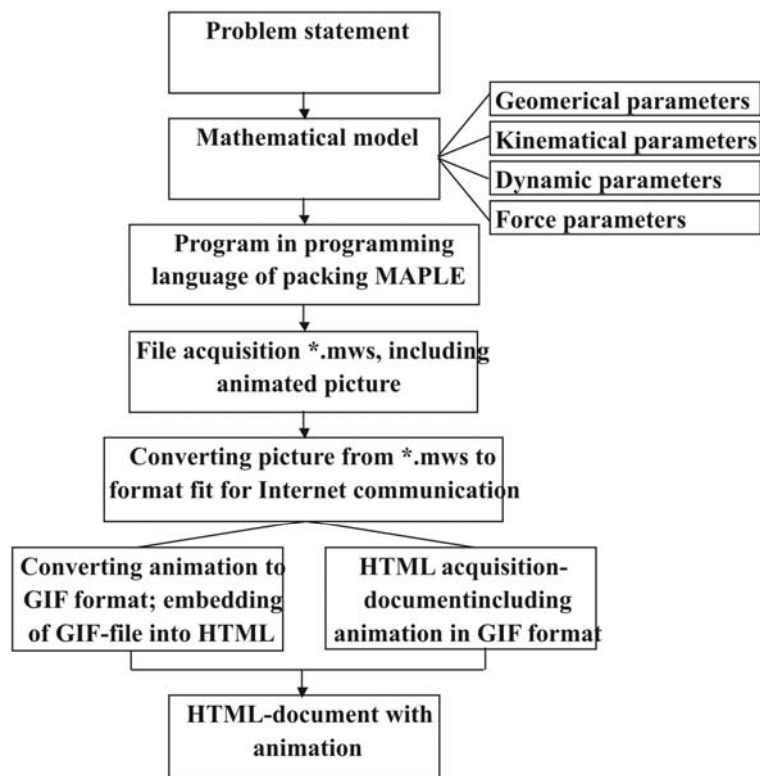


Fig. 8. Production of animated models in packing MAPLE

1). Problem statement includes the description of input and output parameters.

2). Composition of mathematical model of mechanism: description of geometrical, kinematical, force and dynamic parameters is used depending on handling a problem:

- geometrical parameters: link dimensions, coordinates of datum points, link slopes with respect to axis;
- kinematical parameters: velocities, accelerations of datum points, angular velocities and acceleration of all links;

- force parameters: loads (single and distributed forces, moments), applied to parts of a mechanism;
- dynamic parameters: mass, force and moments of inertia.

3) A new program is being prepared on the base of a constructed mathematical model in the built-in programming language MAPLE.

Coordinates x_A, y_A, x_B, y_B of points A, B of a mechanism are defined as time functions (in the interval from 0 to T , where T - is a time period of one revolution of AB crank), and links OA and AB are set as lines with coordinates $\{(0,0), (x_A, y_A)\}$ and $\{(x_A, y_A), (x_B, y_B)\}$ accordingly and slider B - as a rectangular.

2D-model of a crank mechanism (is included in file *.mws) is the result of executed program. Some frames illustrating the position of mechanism at any instant are shown in fig. 9.

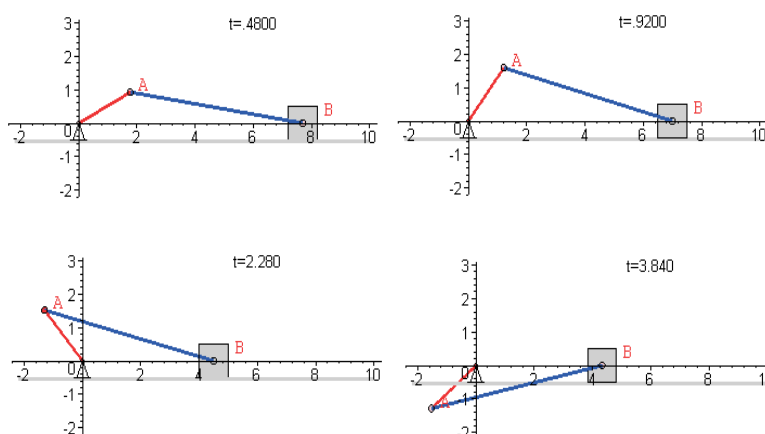


Fig. 9

4).Converting. Manufactured model is converted into WEB –format (CIF) and is built-in into HTML-page.

B). Animated system of designing SOLID WORK together with program set DYNAMIC DESIGNER MOTION (ADAMS) is used as alternative environment of computer modeling.

Let us consider the acquisition of 3D solid model as illustration of crank mechanism.

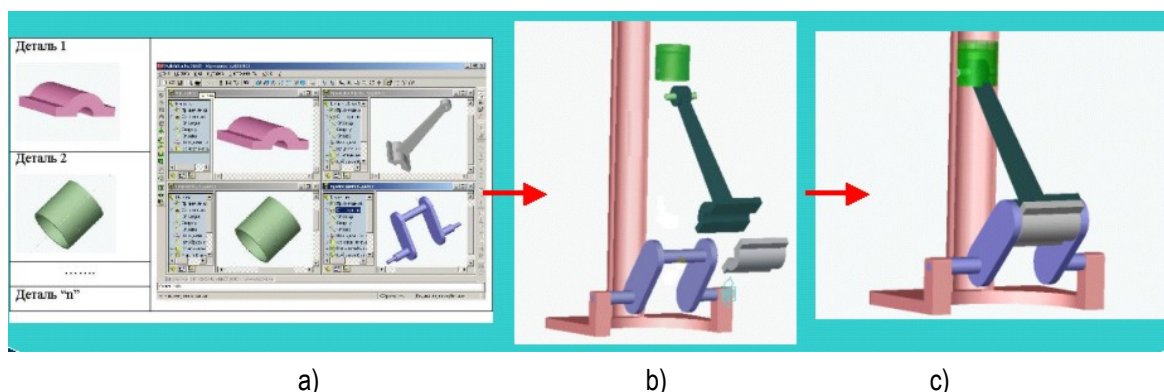


Fig. 10. Design of three-D parts

The first stage-formation of 3D parts of a mechanism (Fig. 10, a) and it is necessary:

- a) to draw a flat sketch, made with the help of simple primitives, entering an outline;
- b) to “define” an outline (preset dimensions, correlations: parallelness, perpendicularness, concentricness, equality, etc.);
- c) to design 3D parts (outline drafting by pressing out along directive, rotating along the axis, drawing jackets, holes, bevels, etc.)

The second stage-uniting parts into assembly (Fig. 10, b) with the help of applying so called "integration" on them (conditions, coincidences, parallelness, perpendicularness, concentricness, etc.)

Limiting their relative mobility.

3D solid-state parametrical model of a mechanism (Fig. 10, c) is received as a result, the model being passed to the partner systems such as: DYNAMIC DESIGNER MOTION (DDM).

The third stage-receiving an animated model in the packing DDM. In order to do it animated parameters are added to the geometrical model, worked out in SOLID WORKS: leading link is chosen, assigned a view of its movement, the number of frames of animation, time of its reproduction. It is possible to watch colored 3D of moving mechanism, design its single parts in space, and examine kinematics and dynamics on the monitor screen (Fig. 11).

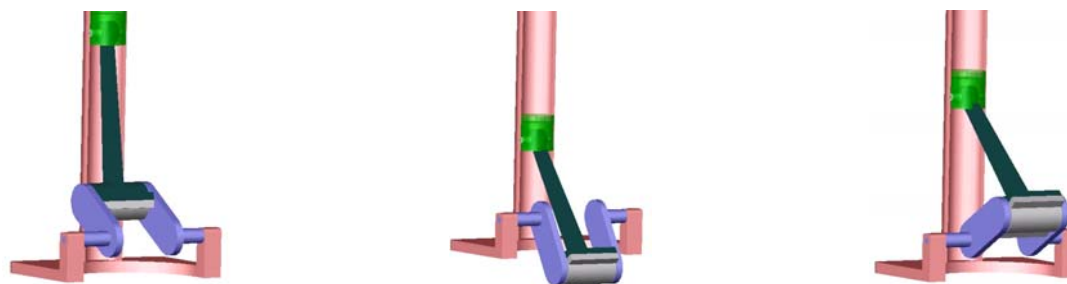


Fig. 11. Crank mechanism in rod running

Received animated model can be kept as a demo reel (in format *.AVI) or in format *.WRL (VRLM, Virtual Reality Modeling Language) which is a standard for passing 3D virtual scripts into Internet. It gives opportunity to embed reference for them into HTML-pages and publish them in Internet.

The fourth stage- display of graphical results. Options of SOLID WORKS and DDM programs help to display designs of kinematical (link velocities and acceleration), dynamic (forces, moments) and other necessary parameters from time to the screen.

Working with such DTS the user can not only study principles of analytical solving of mechanical problems but to become skillful at computer modeling.

Operation with appendix "Tests and problems" helps to:

- learn skills in solving problem;
- exercise self-control of knowledge (local version), intermediate and final control of knowledge (distance version);
- form test tasks (subsystem "Test Constructor")
- carry out monitoring of learners' standard of knowledge.

This subsystem registers the results of tests of each learner, the number of attempts and time spent on answers.

For assessing the proficiency we use such test assignments as: "yes-no", "multivariate choice", "list regulating", "and input of one's own answer".

Appendix "Tests and problems" contains more than 300 test assignments in the sections of theoretical mechanics. At present the base of assessing proficiency is expanding.

Appendix "Laboratory manual in mechanics" contains a set of computer calculated-graphical works; each of them includes the name, aim, short theory, instructions in details for performing the tasks, condition of a problem, variants of assignments. File-samples are given to help a learner to solve standard problems on statics, kinematics and dynamics on the course of theoretical mechanics.

3) Teaching Aid.

Worked out DTS is used together with the teaching aid "Theoretical mechanics on computer". This aid is a practical manual for the work with teaching system in local and distance modes. The manual also contains solution algorithms of standard problems on mechanics in the mathematical packing MAPLE environment,

description of comprehensive calculation of gears and it helps the learners study course of theoretical mechanics for technical universities independently and to solve engineer's problems on computers.

DTS on theoretical mechanics passed evaluation test in the teaching process at Astrakhan State Technical University in 2003 and it showed a good performance.

Problems of program realization were solved when developing DTS. They include the following:

- format choice with due account of their mutual compatibility and opportunity of transfer over Internet;
- choice of compliant software and realization of technological chain development of DTS;
- possibility of providing local and distance operation with appendixes;
- providing of textbook updating, adding new teaching material in particular. In the future it is presumed to develop an integral distance information environment on a mechanical type worked out on the base of DTS, an environment, where it is possible to form an integral array of knowledge elements (such as mechanics) and to realize dynamic access for reference data on various specialties.

Apart from reference and teaching theoretical material there will be provided model opportunities, control functions and administering.

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DESIGN STANDARDIZED WEB-COMPONENTS FOR E-LEARNING

Andrey Belonogov

Abstract: *In this paper a flexible approach to design LMS with QTI Ready component based on the e-Learning standards AICC and IMS QTI is described. This system and component permits a dynamic learning and assessment process. QTI Ready component can provide these facilities to other real world virtual learning management system.*

Keywords: *Web-based education, e-Learning technologies, metadata schemes, standardization and open standards, Servlet technology.*

ACM Classification Keywords: *D.2 Software engineering – Standards: D.2.11 Software Architectures - Patterns (e.g., client/server, pipeline, blackboard); H.3.5 Online Information Services - Web-based services*