# SYSTEMS OF COMPUTER MATHEMATICS OF EDUCATIONAL APPOINTMENT AS A MEANS OF RECEPTION OF PROCEDURAL KNOWLEDGE

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**Abstract.** This article discusses a system of computer mathematics for educational purposes with intellectual properties oriented to support practical activities of users - students and teachers. Are presented of general theoretical and methodological bases, the functional requirements are formulated to systems of computer mathematics of educational appointment and the models are developed of systems of computer mathematics of educational appointment as systems of support of learning processes

**Keywords**. systems of computer mathematics of educational appointment, educational software, procedural knowledge

## INTRODUCTION

Informatization of social activities, including computerization of educational and research activities is one of the key technological problems in development of information society in Ukraine [1, 2].

Above development of complexes of the programs for systems of the automated training and scientific researches, scientific groups are working on problems related to the use of ICT in education. Note, first, basic scientific research center on the use of ICT in education and science - Glushkov Institute of Cybernetics of NAS of Ukraine, the International Research and Training Center for Information Technologies and Systems NAS and MES of Ukraine, Kyiv national university of Taras Shevchenko, Kharkov national university V.N. Karazin, Kyiv national technical university "Kyiv Polytechnic Institute", Kyiv national pedagogical university of Drahomanova, Kherson State University (KSU) and others.

Over the last years Ukraine has intensified processes of informatization of education. In this regard, special relevance acquire general scientific, methodological and technological problems related to the organization of processes of creation, maintenance and effective use of educational software. But at present theoretical problems are poorly investigated and associated with the level of intelligence of educational software that depends on mathematical models of the corresponding domains.

Exact and natural sciences occupy a special place among the disciplines at school and universities. They form the fundamental scientific knowledge, based on precise mathematical models and methods. The educational process for these courses should include not only lectures and seminars, but also active learning: workshops, laboratory work, practical work, etc.

Listed characteristics dictate specific intellectual and architectural properties of information technologies for use in education in these disciplines.

There is a contradiction between the potentially wide intellectual properties of modern professional systems computer mathematics (PSCM), which are using character conversion methods and computer algebra, and the practical impossibility of effective enforcement PSCM in the learning process.

This contradiction can be solved by the creation of systems of computer mathematics of educational appointment (SCMEA), in which intelligent capabilities PSCM are focused on solving specific problems to support the learning process.

Under SCMEA we understand software systems for educational purposes with exact and natural sciences and other disciplines that use mathematical models and methods of subject areas, based on the technologies of character transformation and methods of computer algebra.

General model of SCMEA is the model predictive software that corresponds to the forms of organization of educational process, focused on all participants in the educational process and all kinds of learning activities based on knowledge of the subject domain.

SCMEA provides the formation of a declarative (factual) and procedural (algorithmic) knowledge.

Declarative knowledge (descriptive knowledge) - a knowledge that recorded in the memory of the intellectual system and are used to provide information about the properties and facts of subject domain.

Procedural knowledge (algorithmic knowledge) - is knowledge that stored in memory intellectual system as a description of procedures, methods, instructions to convert data, in other words - a knowledge of methods of the solving of tasks.

Intellectual properties of SCMEA are provided implementation of specific tasks of support of process of the decision of educational mathematical tasks, the methods of implementation which are based on mathematical models and methods of relevant subject areas and use efficient algorithms for computer algebra.

Thus, the purpose of the given job is research of general theoretical and methodological bases, formulation of the functional requirements to SCMEA and development of model of SCMEA as systems of support of learning processes of on the basis of the analysis of the topical forms and features of processes of learning from exact disciplines

# 1. THE OUTLINE OF THE PROBLEM

The development of intellectual mathematical software was created at the Institute of Cybernetics NAS Ukraine by V.M. Hlushkov in 1965. At the Institute of

Mathematical Machines and Systems NAS of Ukraine areas related to computer algebra and symbolic transformation technologies are actively developing (system ANALYST) [3-5]. In the late 80's at the Institute of Cybernetics the first version of algebraic programming system APS was developed, which in the early 90's was used to develop the first prototype MECMS (AIST system).

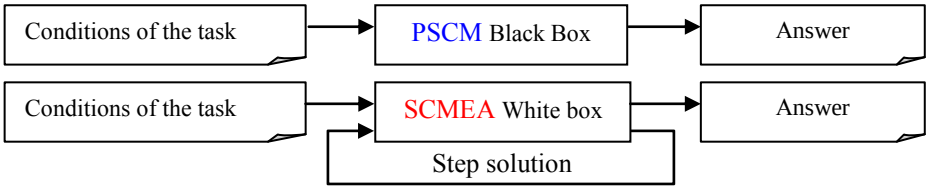
Market analysis of software for educational purposes with the exact and natural sciences shows that the majority of computer courses in mathematics, physics and other disciplines with traditional structure and functionality, is based on general ideas and principles of programmed instruction, while using all the hardware and software capabilities of modern computer technology and new methods of knowledge representation. A lot of Ukrainian and Russian software of this type were created: GRAN, DG [132-134]; Geometer's Sketchpad, Cabri Geometry, Cinderella, Geometria, GRACE, DreamCalc, PowerOneGraph, etc.

The most advanced and sophisticated from both methodical and technical point of view is the lecture part of the course. Typically, the educational material of the lecture is accompanied by system of control questions and tests. This computer system provides far incomplete, indirect control of knowledge. A mathematician should be able to solve the problem; a programmer should be able to write computer programs. These professional skills are formed during active forms of learning: practical exercises and laboratory work. Making practical skills is achieved here, and this part of the curriculum in many disciplines (mathematics, physics, computer science ...) is central.

The functionality of this software is limited only by graphical and computing tasks. Functions that require symbolic manipulations and computer algebra methods, they do not perform. From our perspective, these properties are crucial for creating effective intellectual PCMS in mathematics, physics and other exact and natural sciences.

Market introduction of professional systems of computer mathematics (PSCM) led to intensive implementation of the learning process and numerous educational researches on the application PSCM in learning mathematics [8, 9]. Typically, to support workshops Methodist recommend using universal computer algebra system (CAS) - Mathematics, Maple, Mathcad [10], Derive [11] and others. However, from our point of view, the use of PSCM in the learning process is somewhat limited.

Firstly, PSCM are designed for solving mathematical tasks, while software of educational assignment (SEA) of mathematics must support solving mathematical tasks. This specificity is known as the principles of black and white boxes (pic. 1).




Pic. 1. The principle of black and white boxes.

Secondly, PSCM do not contain didactic materials. User Manual PSCM can not substitute for a textbook or Taskbook in mathematics. Thirdly, the interface of PSCM is not focused on high school students. PSCM usually do not even use specialized mathematical editor, only line editor with limited programming syntax. These limits can be extended.

Some foreign software for educational purposes, realized on the basis of the white box exists now. All these programs generate the course of solving the task for her condition.

1. Answer Ace, Formulae 1, Universal Math Solver - step by step solver algebraic tasks.

2. Bagatrix Geometry Software Bagarix Algebra Software, Bagatrix Trigonometry Software, Bagatrix Graphing Software - step by step solver of mathematical tasks with graphics capabilities support.

3. KwikTrig - step solver of trigonometric tasks.

An exception is an integrated software environment «WebAlmir», learning the basics of linear algebra (supervisor - prof. Spivakovsky O.), which comprehensively supports the learning process [12-13].

Making a summary overview of educational software with mathematical disciplines, we note the following:

There are several functional types of specialized software for learning mathematics on the global market of software. Firstly, a teaching program such as electronic books, which offer users didactic material and system testing of acquired knowledge. Secondly - this software supports practical user experience of computing, graphics and geometric constructions. Thirdly - it step by step solver educational tasks. The most specialized software can combine a few of these functional types. Yet each of these software tools is focused on different stages of the educational process and separate categories of the educational process.

Universal computer algebra systems (UCAS), which are positioned as being suitable for use in the educational process, are operating on the principle of black box. They contain no electronic teaching materials (textbooks, books of problems, etc.). From our perspective, they focus more on the application in the study of applied sciences.

The practice of using PSCM in the learning process has shown that they do not solve all the problems related to the efficiency of the learning process. There are specific tasks that require the development of new algorithms and specialized software systems for educational purposes, based on the technologies of symbolic transformation algorithms and computer algebra [14, 15].

## 2. MODEL OF LEARNING PROCESS

The development of educational technology, due to many factors (rapid increase of amount of theoretical knowledge of professional requirements to specialists as the sum of professional competence; internationalization of educational processes, widespread complex professionally-oriented information systems, rapid distribution

and penetration into all areas of the global information and communications network, etc.) defines a fundamental change in educational technologies [16]:

– widespread use of effective information technology focused not only on classroom work - the work of the teacher and the students, but also on the individual work of the teacher-student, student's individual work, both in the classroom and beyond;

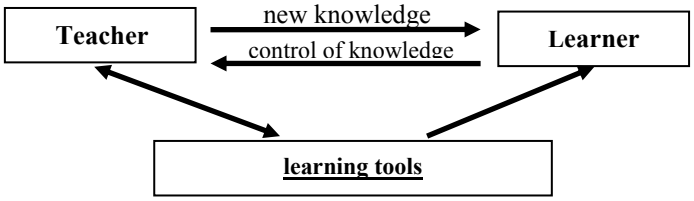
– widespread use of distance learning not only in higher education but also in secondary and vocational schools;

– individualization, increased internationalization of the learning process;

– widely used forms of remote access to knowledge, creating entirely new conditions for the organization of independent work.

Really requested information systems which are based on the concepts of three-subject of didactics [13]. This model considers the active participation in the learning process of teacher, student and ICT as tools for knowledge representation that support the learning process.

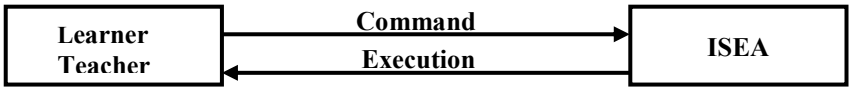
Our understanding of the learning process model is presented in pic. 2.




Pic. 2. The learning process in three-subject didactics

The concept of information systems of educational appointment (ISEA) is in comprehensive automation support of the learning process, whose main participants - the teacher as a professional, a carrier of knowledge in the field of didactics and teaching methods, in the subject area, and the student as an object of study.

The principle of interaction of users in ISEA is presented in pic. 3.




Pic. 3. The principle of interaction of users in ISEA

The main goal of ISEA is comprehensive software of learning process.

The main tasks of ISEA:

MT1. Ensuring the relevance and accessibility of educational means.

MT2. Support for the transfer of new knowledge.

MT3. Support knowledge control (feedback).

In accordance with the general schemes the application of ICT in the learning process, we offer conceptual methodological requirements for information systems of educational appointment:

MR1. ISEA must match the form of the educational process.

MR2. ISEA should focus on all participants in the educational process.

MR3. ISEA should focus on all kinds of training activities.

MR4. ISEA must be based on knowledge of the subject area.

Thus, the problem of the study can be defined as the study of general theoretical and methodological foundations, the functional requirements of mathematical models and methods, technology and tools create SCMEA satisfying conceptual and methodological requirements 1-4 and solve the tasks MT1-MT3.

## 3. INFORMATION MODELS FOR PROVIDING OF PROCESS OF STUDIES DISCIPLINE

The form of organization of learning process (class-lesson) from certain discipline is regulated by curriculum course. This document is the basis for determining the content of documents and next didactic materials:

- thematic lesson's plan of discipline,
- textbooks and educational manuals,
- taskbooks,
- libraries of supporting abstracts (visual aids),
- summaries of lessons,
- copybooks,
- examination tasks (tickets),
- methodical manuals and recommendations for teacher,
- glossaries and reference book (subject domain).

The set of didactic materials determines the methodology of learning discipline. Methodology author (Methodist) in the model of three-subject's didactic, along with teacher and student, is principal of the learning process.

Educational technology (ET) plays an important role in information support of educational process, regardless of the form of educational process. There are blackboard, video projector, ruler, calculator, laboratory equipment and other ET. A special role is played here by the computer as a universal means of modelling other ET. For learning subjects, in which the basic is procedural knowledge, ET realize the important function of supporting practice.

Models of didactic content ISEA. Information basis for modelling software ISEA is structural and logical schemes (SLS) of subject domain - speciality, discipline, a training module.

SLS of subject domain is a directed graph without cycles, which is the basic unit of domain knowledge and logical relationships between them, which determine, in particular, the sequence of the study of knowledge units. In our opinion, the SLS should represent a three-level hierarchy:

"speciality" - "discipline" - "training module"

SLS of speciality is the logical relationship between the disciplines of speciality. The SLS of discipline (SLSD) is a logical relationship between the training modules. And SLS of training module (SLSM) is the logical relationship between the concepts of the module.

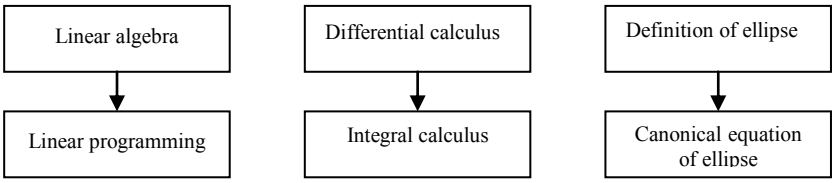
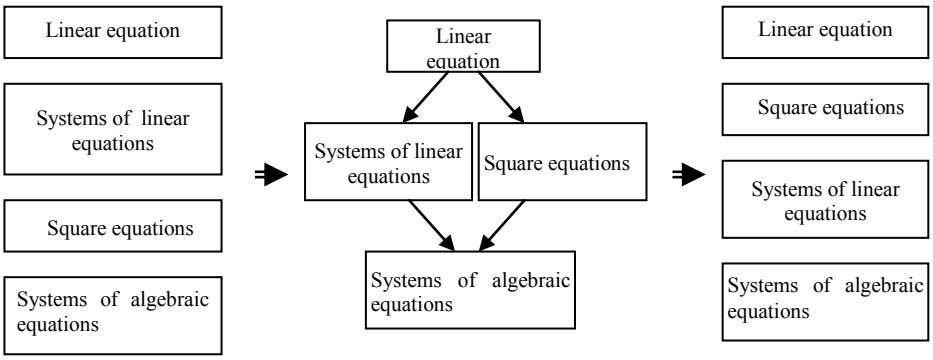



Рис. 4. Fragments of SLS of level "speciality" - "discipline" - "training module".

Models of representation of the level of learning module are described in engineering knowledge. There are semantic networks, frame model, object-oriented model. A well-known model of mathematical knowledge is semantic (algebraic calculating) Tiugu network. Below we describe the mathematical model representation of the procedural knowledge of systems of computer mathematics of educational appointment

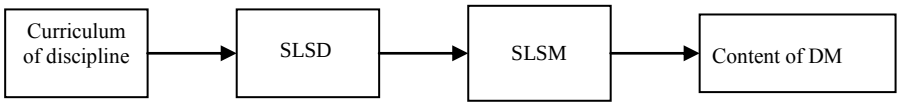
The model of information support of mathematical discipline is a reflection of the content of curriculum discipline in SLSD and a reflection of SLSD in SLSM, which carries out linearization of SLSM.




Pic. 5. A reflection of curriculum discipline in SLSD and curriculum of discipline.

The basic structural unit of information support of learning process is the training module. SLSM from mathematical discipline defines:

- the contents of didactic materials (DM);
- Signature of learning module;
- A list of mathematical models of learning module;
- A list of elementary transformations of models of learning module;
- A list of types of training tasks of learning module.




Pic 6. A structure of representation of knowledge of educational discipline

The signature of learning module. Mathematical theories, which are taught in the module, using mathematical symbols (operations, predicates, functions). For example, Trigonometry module introduces the characters of trigonometric functions and inverse trigonometric functions, symbol of constant $\pi$. Integral calculus module introduces symbols of indefinite and definite integrals, special symbol of constant C, symbol of substitution $\Phi(x)|_b^a \overset{df}{=} \Phi(b) - \Phi(a)$. The list of these symbols consists of the signature of a learning module. Full signature of this module consists of own signature of module and signatures of modules on which this module depends in SLSD. The subject of study is the interpretation of the signature in this learning module.

Mathematical models of learning module. To mathematical models of a learning module belong to the formal definition of mathematical objects that are the subject of study. In the training module Trigonometry it is, for example, the formal definition of trigonometric expressions, trigonometric equations, etc. Graphical tools play an important role in the presentation of mathematical models. Generally, mathematical models of applied learning modules, can and should be presented in the form of graphs, figures, charts, etc. Therefore, the formal definition of mathematical objects include information about the parameters them of graphical representations.

Educational tasks of learning module. The main subject of study in the learning module of mathematics and exact disciplines is educational tasks, the list of types defined in the curriculum of discipline. It are so-called standard tasks solving skills which are the requirement of the state standard (the educational professional program (EPP). The formal definition of educational task $P$ includes model of task $M(x_1,..., x_n)$, condition of task $\varphi(x_1, ..., x_n)$ and question $Q(x_{j_1}, \ , x_{j_m})$.to it ($P = <M, \varphi, Q>$). The definition of educational task can be interpreted as:

Given $M(x_1, ..., x_n)$ and $\varphi(x_1, ..., x_n)$. Find $Q(x_{j_1}, \ , x_{j_m})$.

For example, the task: Build a tangent to the graph $F$ the function $y = \frac{x+1}{x}$ at point $A$ with the abscissa $x_1 = 1$ is submitted a model:

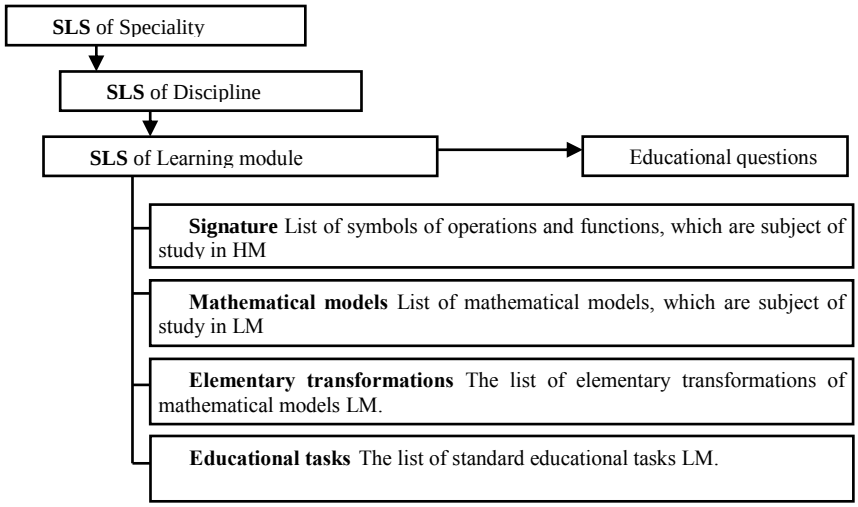
$$M = F(y = f(x)) \,\&\, A(x_0, y_0) \,\&\, L(y - y_0 = f'(x_0)(x - x_0)) \,\&\, (y_0 = f(x_0))$$

condition $\varphi = (f(x) = \frac{x+1}{x}) \,\&\, (x_0 = 1)$ and question $Q = ?L$.

Let's note, that model and questions of a task contain of model of function $y = f(x)$, points $A(x_0, y_0)$ and straight (tangent) $y - y_0 = f'(x_0)(x - x_0)$. Letter designations *F, A, L* mean that these models have graphic images that are on the chart are designated by the appropriate letters.

Elementary transformation of models**.** The process of solving the educational task is defined as a sequence of steps, above each of which is carried out one from elementary transformations $M \,\&\, \varphi \,\&\, Q$. For each learning module is defined specific transformation. A complete list of elementary transformations of this learning module consists of specific transformations of this module and transformations of modules on which this module depends in SLSD. For example, specific for learning module Differential calculus is the rule of differentiation and table of derivatives elementary functions. The module Application of derivatives, which depends on the

module Differential calculus in SLSD, in particular, contains the elementary transformation which consists in drawing up the equation of the tangent to the graph of the function. Model didactic contents is shown on Pic. 7.




Pic. 7. Model didactic contents of ISEA from speciality

Thus, the formal definition of the learning module (Subject Domain) is defined by the quartet $SD =< \Sigma, MM, ET, Task >$.

If the learning module in the SLS discipline depends on the modules $SD_1,...,SD_k$, then $\overline{\Sigma}_{SD} = \bigcup_{j=1}^{k} \overline{\Sigma}_j$ where $\overline{\Sigma}_{SD}, \overline{\Sigma}_j$ - full signature modules (set of all functions and operations symbols defined in this module). Similarly $\overline{ET}_{SD} = \bigcup_{j=1}^{k} \overline{ET}_j$. These parities are a formal definition of the modular structure of the learning discipline and speciality.

## 4. ANALYSIS AND FUNCTIONAL REQUIREMENTS TO MEANS OF TEACHING MATHEMATICAL DISCIPLINE

The content of educational discipline for form of organization of learning process (class-lesson) has the following structure:

Academic discipline (*name*)
Subject (*number, name*)
Theoretical questions (*number, name*):
Content // Definition, Properties, Theorems, Proof, Examples …
Practical learning objectives:

Content // Types of educational tasks. Methods for solving of educational tasks.
Thematic tests (*Number*, *Name*)
Content // Options for thematic inspection work

The content of educational discipline for form of organization of learning process (lecture-audience) has a next structure:

Academic discipline (*name*)
Educational Module (*number*, *name*)
Lecture module
Content // Definition, Properties, Theorems, Proof, Examples …
Practical module.
Content // Types of educational tasks. Methods for solving of educational tasks.
Laboratory module
Lab (*number*, *name*)
Content // Objectives of
Content // Report on
Module self-study
Content // Theoretical questions
Content // Types of educational tasks. Methods for solving of educational tasks.
Modular control tasks
Content // Options control tasks
The final (exam or Scoring) problem
Content // Options exam objectives

From all (electronic) of didactic materials with discipline it is possible to extract the group of materials that contain educational information of the corresponding area of knowledge. These are Textbook, Taskbook, educational manuals, library of supporting abstracts, reference book, summaries of lessons, exercise book, glossaries others. Each of these ДМ is intended for providing of certain form of lesson, type of educational activity and oriented on a specific category of users.

Functional requirements for the content and structure of the author`s teaching materials of different forms of organization of learning process (class-lesson and lecture-audience) are the same. Each of these documents has its author. Note that at this point the role of methodist and lecturer are essentially the same. The role of the teacher can be defined as the union of lecturer and teacher roles.

Didactic materials are personalized. The essence of personalization is that DM has the owner. DM owner is an user who has the right to edit the DM due to the needs of its training activities.

Consider the basic functional requirements for electronic DM.

The textbook is designed for self-study of theoretical issues. Its content corresponds to the content of the educational plan (EP). The textbook is "copyright" didactic materials (DM) whose content can be edited only by its author (Methodist). Each tutorial is accompanied by theoretical questions test tasks for self-control.

Taskbook are assigned to store conditions of educational problems. Its content corresponds to the content of the EP. Taskbook are "copyright" DM whose content can be edited only by its author (Methodist). State educational problem: solved (ID Notebook), solving, unsolved. Educational tasks of Taskbook are designed for independent solution and to resolve the lesson. Taskbook contains examples (in several versions) of thematic examinations on each subject discipline. Taskbook

should be used for practical training in independent work of the learner and the preparation of learner and teacher for practical exercises and tests.

Each of the tasks in Taskbook may be open for solutions in Medium of solving (MS). Each of the tasks in Taskbook may be included in the package of tasks for independent or subject test.

Library of the basic abstracts (LBA) are designed to store basic abstracts of each issue of theoretical material. The structure of the LBA must include basic abstracts - test tasks from each issue of theoretical material. LBA is "copyright" DM content basic abstracts which can be edited by its author. LBA is personalized DM, the content of additional abstracts can be edited by a teacher. LBA is used to form the outline lesson in preparing teachers for classes. Each basic abstract may be included in the synopsis classes.

Library lessons/lectures (LL) is personified didactic material. Contents of LL is formed by teacher, but must comply with the content of the EP. Each lesson has a number, subject and contains several reference summaries (with LBA) and examples of solving educational problems. Library lessons are made by teacher in preparation for the lesson. Formation is to determine the number, names and content of the lesson and add the class to LL. Contents of LL and each lesson can be edited by teacher.

Notebook is meant to store educational problems that are solved or are in the solution of the user. Notebook is personalized DM, which content can be edited by its (student, teacher, teacher trainer). Notebook has a number and user ID. ID = (role educational_class, surname). Users can continue solving educational task (ET), opening any ET among problem solving. The teacher is able to include ET with notebooks of the lesson. Methodist has to include ET, which is part of notebook, part of any "copyright" DM. The teacher is able to assess each student's notebook from ET.

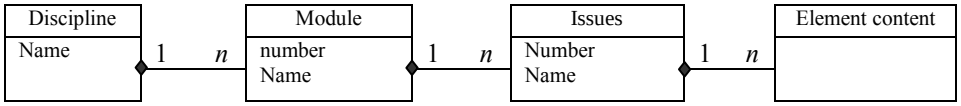
Library of practical employment (LPE) are intended to store the content of practice module. The library also contains practical exercises, which are part of the module work independently. Contents of LPE is formed by teacher, leading workshops (software). Contents of LPE must meet the content of EP. Content can be edited by software trainer. Library LPE is formed in preparation for practical classes. This formation is to determine the number, names and contents of practical classes and adding software to the LPE. Each software has a number, subject and contains several conditions ET.

Library of the modular control tasks (LMCT) are to store options of final work of the training module. Contents of the modular control tasks (MCT) is formed and edited by lecturer. Contents of MCT must meet the content of EP. Each contains a number of options of MCT tasks. MCT is formed from Taskbook and notebook technology shaping lesson.

The main function of the environment of the decisions (ED) is to support the process of mathematical problem solving training in different modes. Here are the basic functional requirements to the ED: export opportunities for learning problems with Taskbook or notebook, store partially solutions or completely solved in a notebook, keyboard entries provided educational task of one of the standard types, select one of the modes of solving educational problem, review progress solving educational tasks.

Here are the basic functional requirements of the FSA: the ability to import the learning task from the Taskbook or exercise book; the ability to save solution process of task fully or partially in exercise book; the ability of keyboard input of condition of an educational task of one of the standard types; the ability to select one of the modes of solving the learning task; the ability to review the process of solving the learning task.

Basic unit of DM content is educational issues. However, educational issues are structured documents, in turn. The structure DM is described by diagram on Pic. 8.




Pic. 8. Chart objects Content-DM content.

- EC1: definition, theorem, lemma, corollary, an example, task, exercise.
- EC2: proof, remark, comment.
- EC3: explanation.
- EC4: table, picture (diagram, schema, ...).
- EC5: numbered formula.
- EC6: graphic, animation.

There are the relevant syntactic definition:

Number :: = <Module number>. <Question number>. <Own number>
EC1 :: = <Title1> <Number>. <Content>.
Title1 :: = Definition | Theorem | Lemma | Corollary | Examples | Task | Exercise
EC2 :: = <Title2>. <Content>
Title2 :: = Proof | Remark | Comment
EC3 :: = <Content>.
EC4 :: = <Content> <Title3>. <Number>. <Content>
Title3 :: = Table | Picture
EC5 :: = <Content> (<Number>)
EC6 :: = <Content> <Title4>. <Number>. <Content>
Title4 :: = Graphic | Animation

These definitions are specifications for CASE-technology development of electronic versions of appropriate teaching materials, including schemes of mark-up of documents and editors of DM.

Elements of content (EC) are objects that have specific functionality. Utilities words define appropriate classes. Functions of classes EC are functions of management of relevant EC. As functionality of class depends on the type of DM, EC has the appropriate interface for each DM.

# 5. MEDIUM OF ACTIVITY AS A MEANS OF SUPPORT OF PRACTICAL MATHEMATICAL ACTIVITY

Practical mathematical students activity (student) is the main form of educational activity in the study subjects, based on mathematical models and methods. Its sense is in solving learning math problems.

Practical mathematical activity has certain characteristics. Her educational goal is to build the course of solving educational problems but not getting answers. That is why object-oriented information systems of educational appointment (ISEA) in mathematics, that SCMEA must support the process with mathematical problem solving. From a technological point of view, information support of the resolution of educational problems is possible, only if its solution is in a specialized software module - active environment. Active environment is the main software modules of SCMEA.

One of the most important aspects of practical mathematical support of the student is validation of the performance of his actions at various stages of problem solving - from the stage of construction of mathematical models and finishing stage of checking process solutions or answers. The second, equally important aspect of support - Automation of routine activities associated with the calculations. The third aspect - providing convenient student of tips in various stages of solving the problem as a mathematical model generation problem, move or step of the solution, answer.

Practical mathematical activity of the teacher should also be supported. The first aspect of this support - checking process of solving the problem. The system has to check the correctness of the course of solving the problem, unleashed earlier (Test mode control work).

The second aspect of teacher support - Automation of testing students' knowledge. Specific activity-environment is to verify knowledge of basic mathematical rules and formulas (special test that uses mathematical tests).

A condition for the effectiveness of the support system of practice is the ability to use planned, in accordance with the requirements of the curriculum system of teaching material support, practical work with the possibility of modification.

The system should also ensure effective management of the educational process as a whole, supporting the interaction of teacher and student.

SCMEA must also provide the user with the appropriate mathematical tools (calculator, graphing tools, etc.).

Main functions of support of practical activities were designed. To implement these functions different types of activity-environments are assigned.

*Environment testing*. Testing is the main, the most common technology knowledge control system for educational purposes. However, in practice the system of verification testing are oriented on declarative knowledge. The problem of checking the procedural knowledge needed to be resolved. Systems testing procedural knowledge must be detail-oriented, and algorithms verify answers - based on knowledge of the subject area. Thus, the test of environment practical mathematical knowledge should support math tests.

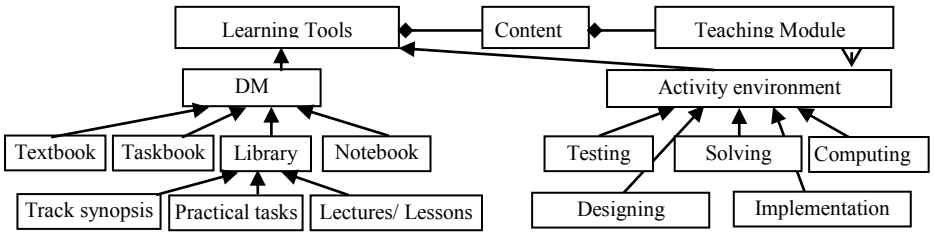
A characteristic feature of mathematical test problem is that the response must be provided in the form of mathematical (logical) expression, and checking answers is to test the semantic correctness of the expression.

Testing of procedural mathematical knowledge can be incorporated into the training sessions of any kind - lessons, lectures, practical classes and laboratory work. Particularly important is the inclusion of testing the content of electronic textbook for self.

*Graphs*. An important methodological role in the study of mathematics have graphic construction. In the course of high school algebra topic "Charts function" is a major cross-cutting themes of the course. That is why to SCMEA should be included graphical constructs - or as separate software modules or as a submodule shipyard.

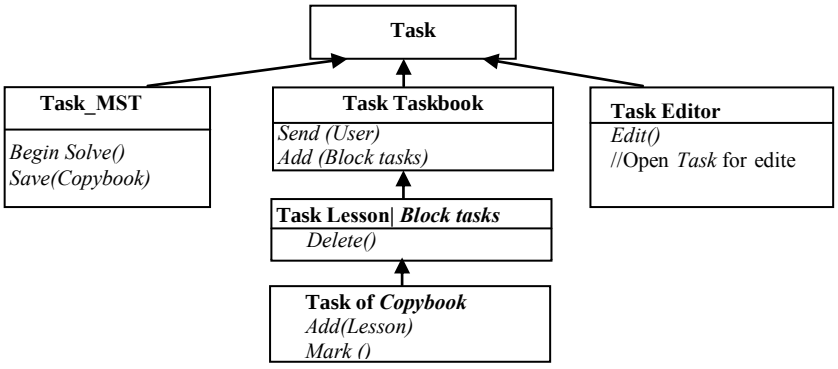
*Environment computing.* The main function of the computing environment is to support learning mathematical problem solving - generating response or move the solution and answers. Note that this environment implements the classic function Solve (), Simplify () professional systems of computer mathematics. The environment should also support algebraic and arithmetic calculations, including approximate calculations required for processing the results of laboratory experiments.

The component of "Learning Tools" we'll describe a class diagram (pic. 9).




Pic. 9. Class Diagram Learning Tools

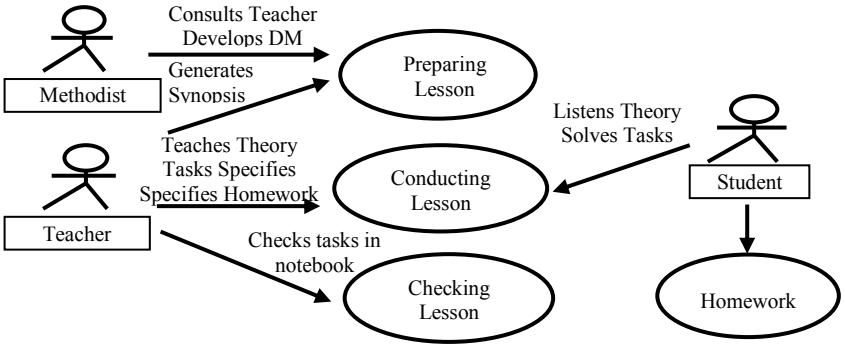
The main feature of the functional class "Task" is the ability to solve task, i.e. to build sequence of steps of solution - elementary transformations (Pic.10) in activity-medium.




Pic. 10. Diagram of class "Task"

## 6. MODELS OF MANAGEMENT OF PROCESS OF TRAINING

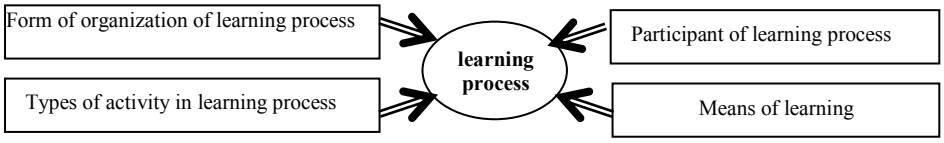
Analysis of the learning process can build basic models of learning management: lessons (pic. 11), lectures, workshops, job control, editing teaching materials consultation.




Pic. 11. Model business precedents “Lesson”

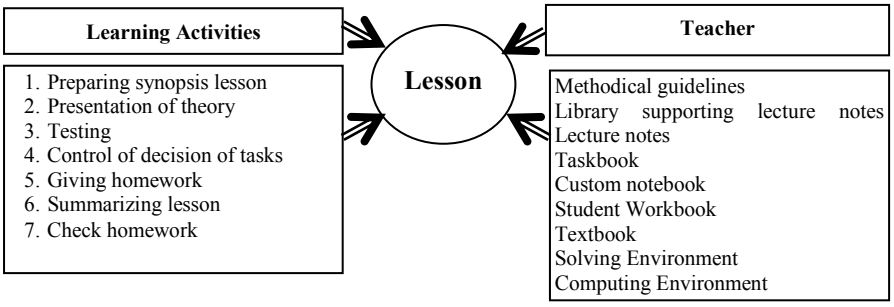
These models, firstly, take into account all stages of learning - from preparation to supply results relevant precedent, secondly show participants learning activities.

The types of activity of business-precedents and means of support of activities (means of studies) we’ll describe on diagram (Pic. 12).

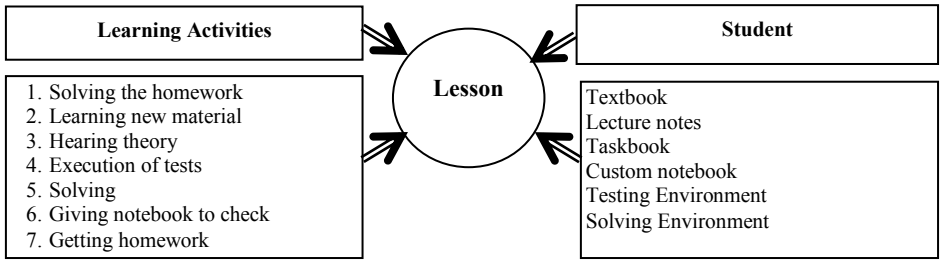



Pic. 12. Skills and Learning Means

These diagrams characterize kinds educational activity of each of the participants of educational employment and appropriate means of training. Examples of the diagrams of kinds of educational activity of the teacher and learner at a lesson are shown on Pic. 13, 14.




Pic. 13. Description of activities and means of learning of teachers




Pic. 14. Description of activities and student learning tools in the classroom.

Teaching process is organized in the form of sequence of lessons, whose curriculum number is defined.

Organization of lesson as a business-precedent for teacher is to prepare for the lesson, conducts lesson and review the results of the lesson. Student's duty is homework, participation in lesson and completion of the lesson.

## 7. IMPLEMENTATION OF THE CONCEPT OF SYSTEMS OF COMPUTER MATHEMATICS OF EDUCATIONAL APPOINTMENT

The implementation of the concept SCMEA long engaged scientists of the department of computer science, software engineering and economic cybernetics Kherson State University.

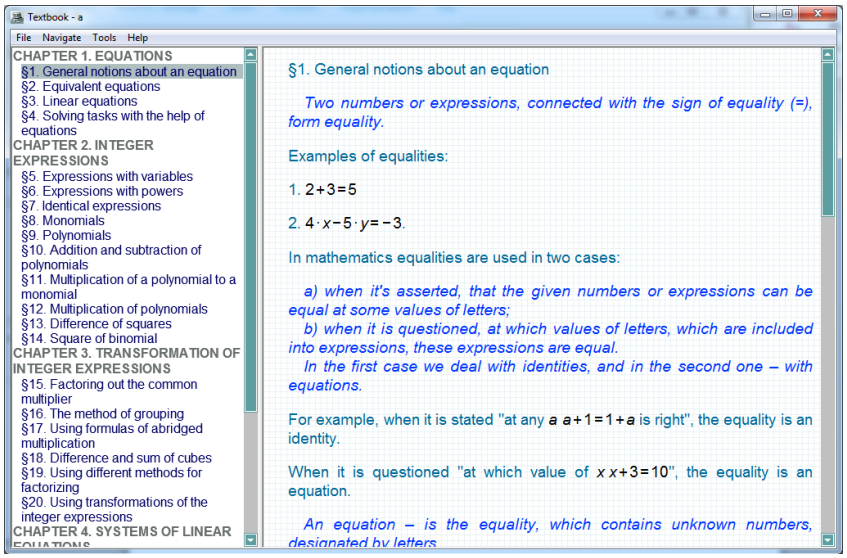
The research were carried out during execution the scientific and technical work on government contracts and state program "Information and communication technologies in education and science" and based on the experience received by development of ISEA, performed by order Ministry of education and sciences (copyright certificates [1-6]):

- Program-methodical complex «TerM VII» of support practical learning of mathematical activity.
- Software tool "Library of electronic visual aids Algebra 7-9 class for secondary schools of Ukraine."
- Pedagogical software tool "Algebra, Grade 7".
- Software tool of educational purposes "Algebra, Grade 8".

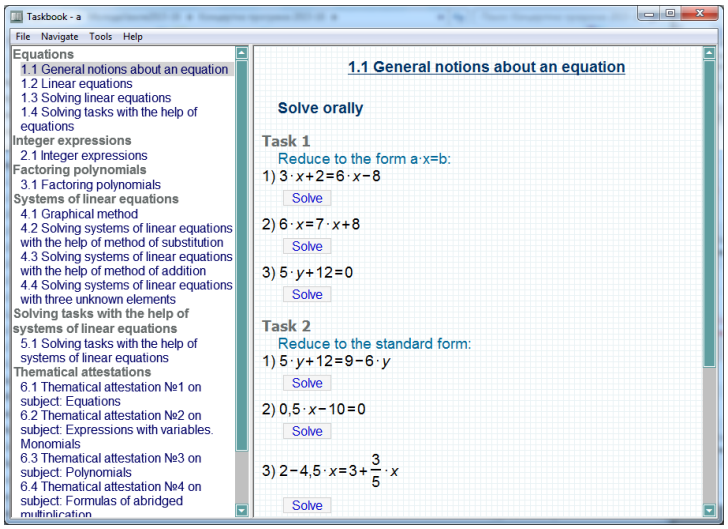
The system approach was offered to construction of models and program realizations of SCMEA concerning construction of SCMEA, which are listed above, which can be used at construction of a wide class of program systems of educational and scientific appointment.

Currently there are several software products, developed using the same technology, one of them has English interface – «TerM VII».

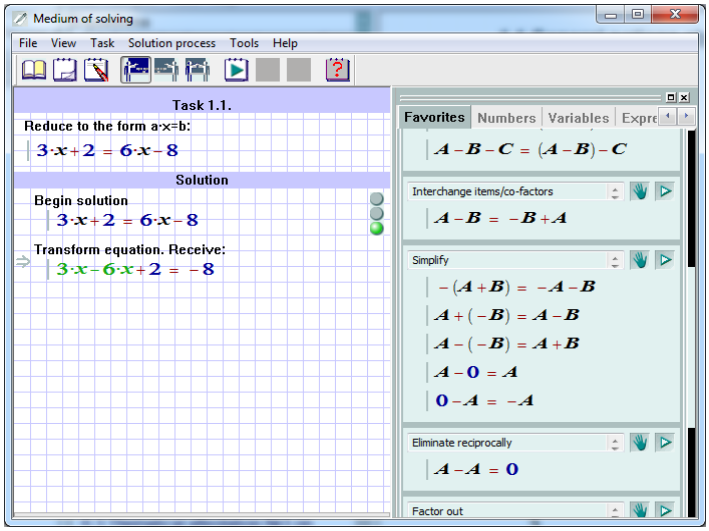

Pic. 15. General view window PMC «TerM VII».




Pic. 16. General view of the page of the Textbook




Pic. 17. General view window of PM "Taskbook"




Pic. 18. Window of the medium of solving with the loaded task.

All SCMEA developed in the framework of this study are used in the educational process in Ukrainian schools. They successfully passed the procedure of certification, the relevant Commission MES, the established procedures of approbation in secondary schools in Ukraine and recommended for use in the educational process (got stamps of MES).

## 8. CONCLUSION

ISEA is a system supporting the learning process, the main objectives of which is to ensure the relevance and accessibility of learning support processes for transferring new knowledge and process control knowledge (feedback).

ISEA should respond to contemporary forms of educational process in schools of various levels, be focused on all participants in the learning process, all forms of workshops and activities participants in the learning process. ISEA must be detail-oriented, based on knowledge of the subject area.

For disciplines based on mathematical models and methods, the system of training SCMEA contains appropriate teaching materials and active environment (computer learning tools designed to support practical mathematical activities of participants of the learning process).

Practical mathematical activity is the main form of student learning activities in the study subjects, based on mathematical models and methods. Its aim is to solve learning math problems.

ISEA is a system which allocated to the jobs of the participants of the learning process. Each of the jobs in its composition has appropriate controls training sessions and types of activities, personalized system of training and tools to support the interaction of participants of the learning process.

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