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SCIENCE LEARNING WITH INFORMATION TECHNOLOGIES AS A TOOL FOR "SCIENTIFIC THINKING" IN ENGINEERING EDUCATION

New methodologies in science (also mathematics) learning process and scientific thinking in the classroom activity of engineer students with ICT (information and communication technology, including also graphic calculator) are presented: visual modelling with ICT, action research with graphic calculator, insight in classroom, communications and reflection of integrative actions. How can we show our students the beauty of science (and mathematics) with ICT and the way scientists think and try to find the truth? Is it possible to create the motivation in science learning for students using ICT or graphic calculator? How can we organize the engineer training on such professional activity in classroom? In this paper we try to answer the questions using methodology of visual modelling and technology of resource lessons in high engineering school including remote E-learning environment .

Keywords: visual modelling, ICT or graphic calculator, resource lessons, engineer education, motivation in science (mathematics) learning.

1. Preamble

In education process for future engineer in science (including mathematics) we remark the lot of opportunities for developing of " scientific thinking" and special engineering skills using information and communication technologies (ICT). Using of the ICT gives rise to new opportunities in increase of motivation and efficiency of problem-solving in science as well as personal and mathematical training of the future engineer ([3], [5], [6], [11]).

One of perspective directions of computerization in a science and mathematical training of engineer is using of computer-aided mathematical systems (CMS) and graphic calculators in scientific research of students in learning of science and mathematics. CMS are universal mathematical packages of symbolical and numerical calculations (MathCad, Mathematica, Maple, Derive and so on) and have joined the category of working instruments for analytical calculations. Using of a graphic calculator in teaching of science and mathematics, being an operative instrument for solving complex computing problems as well as an instrument for recording and visualization of various stages in solving of problems, raises interest to science and mathematics, makes the spectrum of cogitative operations. On the other hand, the future engineer should not treat the ICT only as the object of study of their functions, modes, options, communications in order to solve scientific and didactic problems, but as a tool to control cognitive and communication activity of students in their future professional work as well.

The ICT utilization gives a unique opportunity to increase the level of the personal development of a student: growth of computational and algorithmic culture, development of spatial reasoning and graphic culture, expansion of a cognitive circuit spectrum in thinking processes: perception, understanding, representation, etc. Moreover, mastering of complex intellectual activity leads to acquiring and development of productive thinking of students on the base of scientific thinking and involving the scientific methodology in learning process.

The opportunity of communications as well as using of information ideas in the process of exchange of didactic and scientific experience by students via Internet for distance training and use of electronic working environments as well as training material is of great importance of students more intense and influences the ways of the training contents presentation.

However, there is still some work to do. The experience of the projects mentioned show that most science teachers emphasize in their lessons the content of science; pupils must learn concepts, formulas, laws and models without ICT or some. Education in favour of acquiring declarative knowledge. Yet there are a number of contradictions connected with the ICT use in scientific training and mathematical education of the future engineer, namely:

- between the rate of development of information technologies and the state of teaching of science and mathematics in engineering universities and colleges;
- between opportunities of use the CMS in teaching of science and mathematics and inadequacy of scientific - methodical development;
- between the necessity of creating in students the skill of construction of algorithmic model, while solving a science, mathematical and real problem, and significant volume of the calculations interfering with comprehension of a model structure;
- between the necessity of formation computing skills of students and practical use by students of computer mathematical systems when they solve problems independently.

We understand that scientific thinking of students will be have a background if the essence of scientific recognition is opened and will be have the special educational activity of students in the integration ICT in science oriented on competence based education ([4], [8], [10]). We should pay attention for scientific activity, scientific interactions and cognitive acts similar the scientists work. The good experience in technologies, the materials and infrastructure developed was considered as important for the development of patterns for repeating. We should create the innovative forms (didactical models and technologies) of organization of student activity using ICT in science with high motivation. Therefore we should consider with students the useful , beautiful and essential professional tasks in science learning using modelling and visualization of complex procedures.

In this paper we will emphasize three aspects related to science learning with ICT

and the professional development of engineer in integration process. *First*, we think it is a good idea to emphasize the scientific methodology with ICT ([1-2]). How can we show our students the beauty and use of science and the way a scientist thinks and tries to find the truth? Content, subject matter, will be important, but we should reach the essence of phenomena or process sometimes only using ICT. However, to introduce science for public understanding we must emphasize the thinking process of scientists. It will help the students to get a better understanding of what science and practice is all about and at the same time it will motivate them to learn (more) about science with visualization of algorithmic procedures and adequate mathematical actions. *Second*, we like to modelling the real phenomena and process (including mathematical, science and information models) in integration on different levels with forming the research habits and skills (with the use of ICT). *At last* we would like to form the engineering skills: problem solving in choice situation; operating the evaluation, creating of models of real phenomena and process on the base of visualization and using ICT.

2. Goals

The *problem* of the research: define conditions of the ICT integration into the process of becoming proficient in scientific and didactic problems of science and mathematical learning on the visual modeling basis of objects and processes by engineer students.

The *purpose* of the research: create an integral system (contents, forms, methods and conditions) of research by prospective engineer in solution of scientific and didactic problems of science education involving of the ICT and utilizing visual modeling of basis and processes including remote E-learning environment.

Application of the CMS for solution of scientific and mathematical problems by students will promote growth of motivation in scientific research as well as in professional development of the future engineer on condition that:

- the practice of visual modeling is included into educational activity during integration of science and information knowledge;
- students construct models while solving scientific and mathematical problems with application of the CMS, which record mathematical optimum procedure mathematical and information actions;
- students manifest creative activity while learning to use the CMS (a variation of data and analysis of results, formation of hypotheses and their testing, inter-conversion of the sign systems);
- communicative opportunities for dialogue for groups of students during their educational activity is enlarged by means of information environments (Media, Internet, conferences and so on).

Tasks: (scientific, didactic, information, methodological, professional):

- Study functional possibilities and analyze the basic CMS and Graphic calculator, create the models for modes of work in the information environment;
- Reveal didactic conditions and develop a technique of visual modeling using the CMS (the graphic calculator) during teaching of science and mathematics and solving of scientific problems;
- Develop a laboratory workshop aimed at solving of science and mathematical problems using the CMS (the graphic calculator) and the methods of its conducting for students on resource lessons;
- . Design interactive volume of information by groups of students on the basis of authoring software products and the results of the CMS (graphic calculator) research;
- Visualize the procedure of science and information actions on the basis of improvement of students' computing and logic culture.

3. Scientific methodologies

The results and products of psychology theories and conceptions will be input for a paper where we will emphasize the creative way in which the acquirement of scientific knowledge takes place. They are: competence base education, visual modelling, scientific thinking, integration levels and motivation process. We will answer the question how to introduce the ICT in process of scientific thinking and professional skills forming into the learning process of students in engineering education.. Action research with ICT will be introduced as a tool for future engineer to improve their profession.

Visual modeling of objects and procedures with ICT

The pedagogical *technology of visual-modeling learning* of science and mathematics plays a fundamental role in the proposed didactic system of science and informatics integration of knowledge and actions ([1], [7]). This technology makes it possible to achieve stochastically guaranteed result of teaching of various qualitative levels of learned material as well as integrity of representation of the basic science, information and mathematical structures.

Visual modeling methods of learning present:

- "a priori" modeling the essential links of the object of perception;
- a process of forming an adequate category of ultimate purpose of the learners' internal actions during the process of immediate perception;
- all teachers' managing actions, modeling of separate pieces of knowledge or an arranged set of knowledge for stabilizing the learners' immediate perception.

Let's turn to the definition analysis (Fig.1).

The process of perception of the given visual model presupposes all key qualities of the science, information or mathematical object. It is especially important when information is of great volume (or contains a mix of mathematical (physical) and informatics knowledge or actions). It is necessary to keep in mind such actions when separate pieces of knowledge or an arranged set of knowledge are given. We can deal with proving theorems, solving problems, constructing the algorithm, modeling the real phenomena, learning some parts of scientific and mathematics analysis in its various logical correlations, with a single lesson presentation, a lecture etc.

As has already been mentioned, according to A.N. Leontyev (Russian psychologist), when visual methods of learning and teaching are used, it is necessary to proceed from the psychological role, which they (methods of learning or teaching) play in the perception of new material.

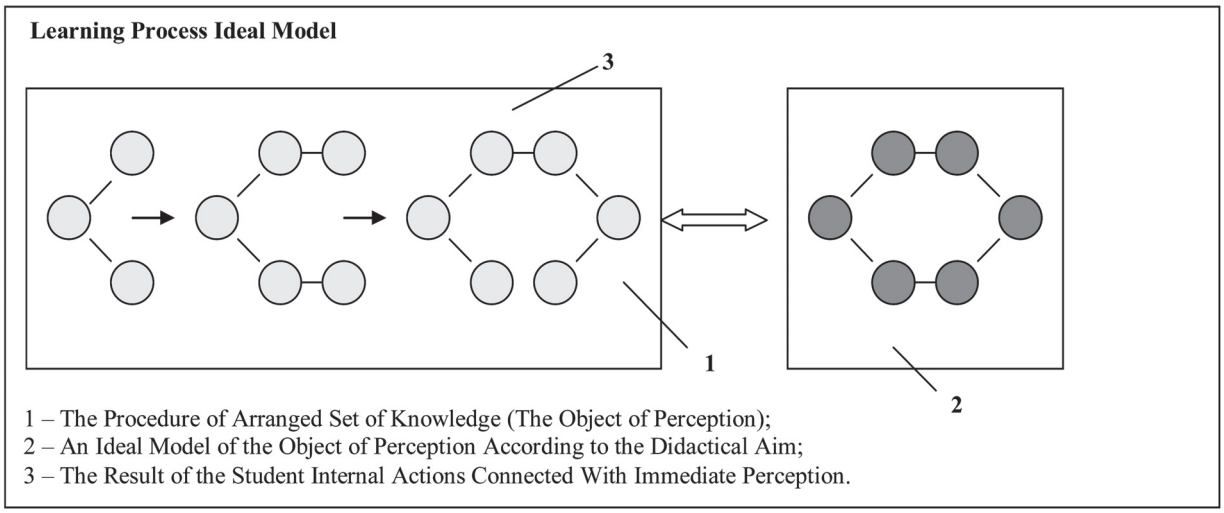


Fig.1 Visual Modeling of Mathematical Object (Procedure)

He chooses two functions of visual methods of learning or teaching:

- the first is aimed at extending the sensible experience;
- the second is aimed at developing the essence of the processes or phenomena under study.

In connection with that, external teacher's actions are divided into bearing and structural actions depending on the orientation of the sensible or rational element of perception.

The external bearing actions can be as follows: writing down formulas, tables, displaying models, drawing up graphs, formulating theorems, programming or logical actions, using text-books or manuals. The structural external actions can be as follows: proving theorems, choosing the main theoretical notions and methods, realizing links between different subjects.

According to our concept use of visual methods in learning or teaching of science of a future engineer is treated as a special property of psychological images of science or mathematical objects, the essence of which is considered in an integral paradigm of perception of the basis of the following criterions:

- diagnosable aim-finding of integrity of the science or mathematical object;
- adequate perception (learner's comprehension of essence of the science or mathematical object in accordance with aims of learning or teaching);
- stability of perceptive image and presentation under conditions of direct perception;
- cognitive and creating activity on the basis of relaxed and successful learning.

We should follow of the next structure of visual modeling as procedure the analysis of science, informatics or mathematical object as a part of scientific thinking (Fig.2)

Future engineer of the target group will develop lesson modules in joint activity to show how a start can be made with introducing scientific thinking in problem solving with ICT. We will use new technologies like computers in the learning environment of the students.

Uniform Environment of E-learning

Intensive development of information and communication technologies (ICT) promotes their using within of educational process at various levels, including in high school. However the basic criterion of ICT application within of educational activity is the organization of optimum schemes of integration ICT with various standard techniques of subject training and independent activity of pupils. The modern period in ICT development can be characterized by two essential tendencies. On the one hand, gradual transition from using ICT of local user by directly on the realization of remote interaction between various users (pupils and teachers) within local or global networks is carried out. On the other hand, gradual transition from using of stationary ICT resources to the ap-

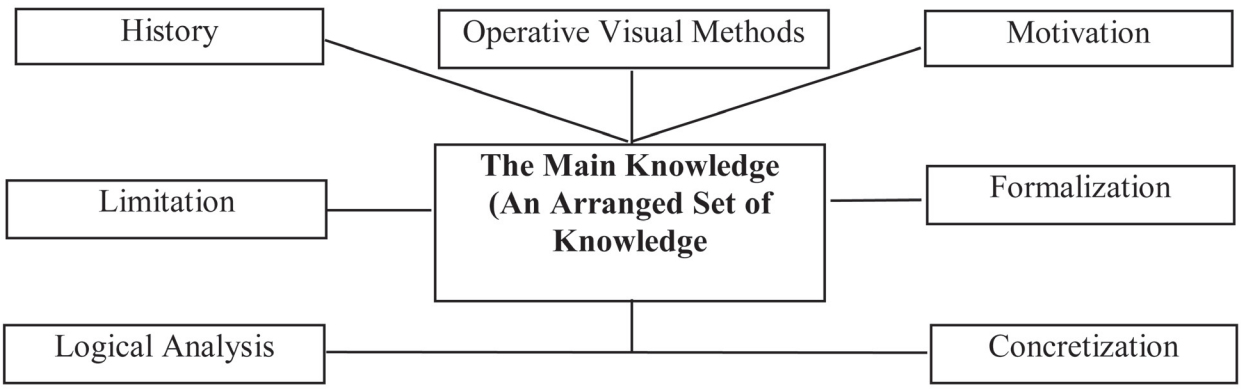


Fig.2. The Structural Analysis of the Key Knowledge

plication of mobile ICT, treated as small resources of information (graphic calculators, a handheld computer, cellular telephones, smart phones, communicators etc.) is observed. It is necessary to notice that now the given directions are considered as completely independent, not having essential points of functional crossing ([12]).

The Organization of remote educational process (REP) within local and global networks is carried out to active using of interaction between pupils and teachers in various operating modes («Prometej», "WebTutor", Moodle, etc.). There are most often used a mode online with direct display of contents, as a rule, in a browser, with necessity of constant connection to a network, or a mode off-line with possibility of necessary material downloading on the local computer with the purpose of further studying without necessity of connection to a network. Two various interconnected environments for work of users depending on their accessory to pupils or to teachers are realized [17, 18]. It is obvious that there are certain distinctions in the organization of work with REP for the given basic categories of participants of educational process.

On the basis of characteristics research of modern REP it is possible to formulate of essential lacks modern REP, used in Russia:

- Absence within REP some realizations of uniform database on teachers and students, considering names of high schools, faculties, specialties, groups and subject matters. It is necessary to underline that the given problem is actual owing to possibilities, on the one hand, teachers to work in several high schools simultaneously, and, on the other hand, as possibilities of training in various high schools, besides on different specialties within one high school as a whole;
- Absence of uniform methodical complex on similar subjects in homogeneous high schools as from the point of view of structure, and the maintenance of methodical and didactic materials. The given problem directly follows from the first problem as absence of a uniform relational database on teachers, students and subject matters directly reflects the absence of a uniform methodical complex in Russia;
- Absence in REP some dynamic resources for realization of educational settlement projects including interconnected works. From the given point of view modern REP are at all adapted for application in educational process of various settlement projects. Unfortunately, available for today REP allows to realize of independent students work only on four components. The *first:* acquaintance of pupils with the lecture contents presented in the form of the electronic textbook. The *second:* testing of students (use both directly total tasks is supposed, and generating of demos) by in advance teacher completely making by manually of questions and corresponding variants of answers to each of them (there are no automated processes, both generation of various values initial given, and logic chains in tasks in general). The *third:* dialogue within of forums or guest books (as a rule, within considered subject matter as a whole), and also the *fourth* possibility of export-import files of documents by user. Now design activity is reduced to creation of presentations and similar documents, that there are no computing and logic projects as those that also is inadmissible. It is necessary to notice that as a whole there are information possibilities of realization not only computing or logic operations within educational projects on science, but also application of various logic chains and operations to realization of educational projects on humanities.
- At the most modern REP there is a monitoring of educational students activity only within total control on a subject matter as a whole. It is obvious that the received estimation only indirectly reflects true level of knowledge, skills of pupils. Absence of the intermediate control on each of sections within subject matter is caused, as it was marked earlier, the absence of possibility on performance of projects and intermediate testing on each of subject sections;
- Absence of intuitively clear and at the same time high-grade system of navigation within REP which finds the negative reflexion in realization of the unfriendly user interface. The given circumstance is caused by necessity of using in REP a considerable quantity of the program modules which are responsible for various functionality, including beyond educational process from the point of view the realization on direct activity of pupils within educational disciplines.
- Now Bogun V.V. is carried out technological working out of information system of REP monitoring of students in high schools which is directed on the decision of absence problem in modern REP of dynamic resources for realization of educational settlement projects. Innovations are presented on the basis of using within of dynamic Internet site some algorithms of problems decision generated on program level with the automated processes of initial data generation, processing and monitoring of intermediate and total results. In particular, the corresponding applied software which is based on using of Web-server Apache for realization of virtual server in a combination to technology of dynamic Internet sites creation on the basis of programming language PHP and control systems by relational databases MySQL for realization of necessary inquiries is developed [21]. REP with strengthening adaptive interactions, constructed on the basis of developed information system of monitoring REP of students is characterized by following features:
- The uniform database on teachers and students within region or the state on the basis of automated account of basic signs (the name of high schools, faculties, specialties, groups and subject matters) is realized. On the other hand, the uniform database under educational projects and studies entering into their structure for necessary subject matters is realized. Applying to teaching mathematics is shown that directly reflects the presence of a uniform methodical complex on subject matters in homogeneous high schools;
- The dynamic system of educational projects from the point of view on necessary of didactic and methodical components of pupils design activity includes the description of the considered course within subject matter. The list of names and the description of corresponding projects within of each course, the list of names, the description, theoretical aspect, demos and settlement tasks on corresponding works within of each educational project is realized. Automated generation of independent variants of demos (values of

the initial given, intermediate and total results) for the teacher and the student with possibility of demos viewing both representatives and administrations only for one of the parties is used. Generation of tasks (variants of values of the initial data) is made for students unitary, the teacher should get access to work of students only in a viewing mode, students should get access to the work with possibility of viewing on correctly specified values, viewing and editing of intermediate before values intermediate and total results. It is necessary to notice that realization of demos and settlement tasks for student activity is carried out according to decision algorithm of corresponding problems developed on programming level within of activity;

- The dynamic system of pupils testing within of subject matter, the project or activity with completely automated processes of values generating of initial data, correct both obviously erroneous results, and checks of answers correctness on test tasks is realized. Possibility of demos generating of corresponding tests, realization of high-grade monitoring of students educational activity within of necessary subject matters from the point of view as disciplines as a whole and taking into account results of settlement projects performance and activity thanking completely automated mechanisms of data processing is thus used;
- Dialogue between students and the teacher in the form of a forum within learning activity is realized that essentially raises clearness of discussed problem borders in forums. It is necessary to notice that the given process means all-around automation presence. Intuitively clear user interface and navigation within of REP owing to use of various kinds of dynamic menus essentially facilitating an access to the necessary information (the hierarchical menu with tree use, the menu with use hypertexts etc.) is applied.

It is necessary to notice that possible to use as didactic material certain sections of linear algebra (a matrix, system of linear algebraic equations, analytical geometry), mathematical analysis (limits and a continuity, calculus, differential equations), combinatory, probability theory and mathematical statistics.

Aims and indicators for success

To reach goals related to our goals as formulated in the preceding paragraph we must:

In relation with *scientific methodology*:

- analyse the (international) experiences on how to attract future engineer to science with ICT;
- investigate whether and how the ideas of students on science and the scientific world change during the project;
- describe learning activities (also including ICT) in relation with "creative and scientific thinking" (paradigm shift);
- design activities that can take place within the regular curriculum and/or during short time thematic projects;
- pilot the develop lesson modules as resource lessons with ICT in engineering education in Russia.

In relation with *action research*:

- introduce the methodology of action research with ICT;
- support future engineer during the process of action research with ICT;
- create and analyse the methodology of resource lessons with ICT and rewrite the modules.
- develop a manual to show future engineer how to implement and use action research with ICT in their professional practice
- develop a manual to show future engineer how to implement the kind of activities we designed during the project.
- create the base of professional oriented tasks with using ICT in different levels and forms.

4. Methods of research

Integration of knowledge assumes possession of the following professional skills:

- Skill to solve a problem (formation of a question, finding of scientific information for solution, analysis of a problem situation, setting up of a hypothesis);
- Capability for science, mathematical and information modeling (definition of the data, conditions and borders of search of the solution, translation of a problem into the language of mathematics, construction of the adequate mathematical device, integration of the solution);
- Skill to apply the ICT;
- Skill of scientific and logical thinking;
- Communication skills.

Integration ICT with Science Learning

It is required to teach students to project and investigate mathematical models utilizing the ICT in such components where their application is necessary and justified (complex computing algorithms, visualization and recording of various stages of science, mathematical or information actions, construction of complex graphic objects, etc.). Thus construction of integrative information model, which optimizes use of an information resource (functions, commands, modes, algorithms, etc.) is a very important problem ([5], [11]). (Fig. 3.)

Developing the genesis of learning element with ICT as pedagogical problem (object for mastering by another subject in learning process with ICT) require the calculation not only mental experience, person characteristic and conditions of activity, but system analysis of analogical substructure of future subject of mastering in new pedagogical conditions.

On next Fig.4 are shown the structure and factors contents which influence on projecting of science objects (process, phenomena) with ICT as pedagogical problem ([2], [7], [8]). (Fig.4)

Remote Training in Uniform Environment of E-Learning

The organization of educational process with using of students monitoring system of REP is carried out on following algorithm:

1. The Formulation by teacher of necessary methodical and didactic components of educational process with using of design activity, including: the description of considered course within of subject matter, the list of names and the description of corresponding projects within of each course, the list of names, the description and theoretical aspect on corresponding activity within of each educational project with the subsequent reflexion of specified components within of students monitoring system of REP;

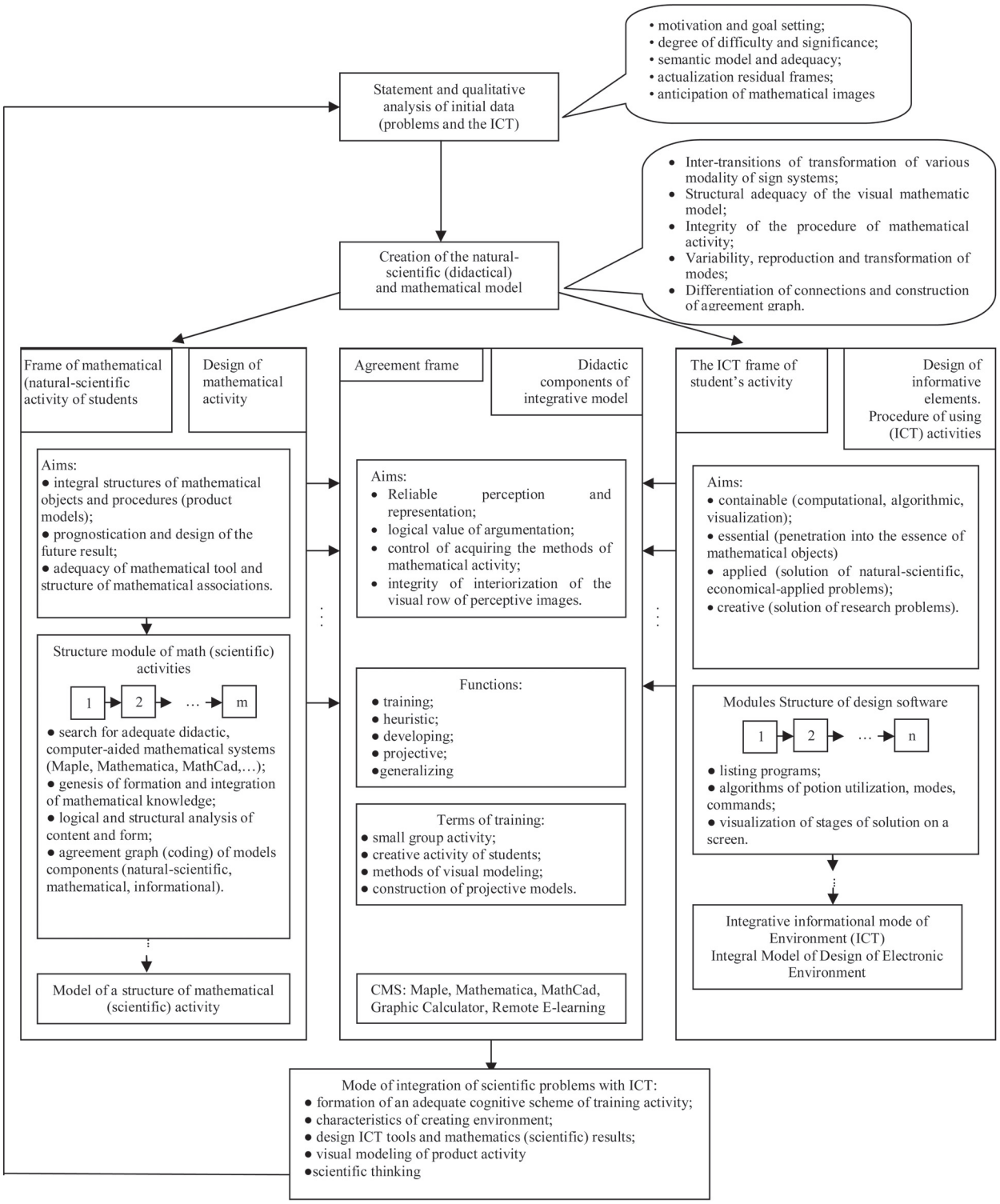


Fig. 3. Integrative model of mathematics (science) and ICT activities

2. Working out of settlement algorithms necessary and corresponding programming modules for realization of each problem decision within of educational project with the subsequent reflexion of specified components within of students monitoring system of REP;

3. Generating by the teacher and students of demos independent variants of considered activity with possibility of demos viewing both representatives and administrations only for one of the parties. On the basis of values generating of initial data with using of random numbers and generated initial code of programming module of problem decision should be receipted of automatically calculated values of intermediate and total results;

4. Generating by each students the corresponding variant of activity with possibility of viewing (not editing) by the teacher of intermediate and total results values and possibility for students of correctly specified values viewing , editing and viewing of current values and intermediate and total results on the basis of values generating of the initial data

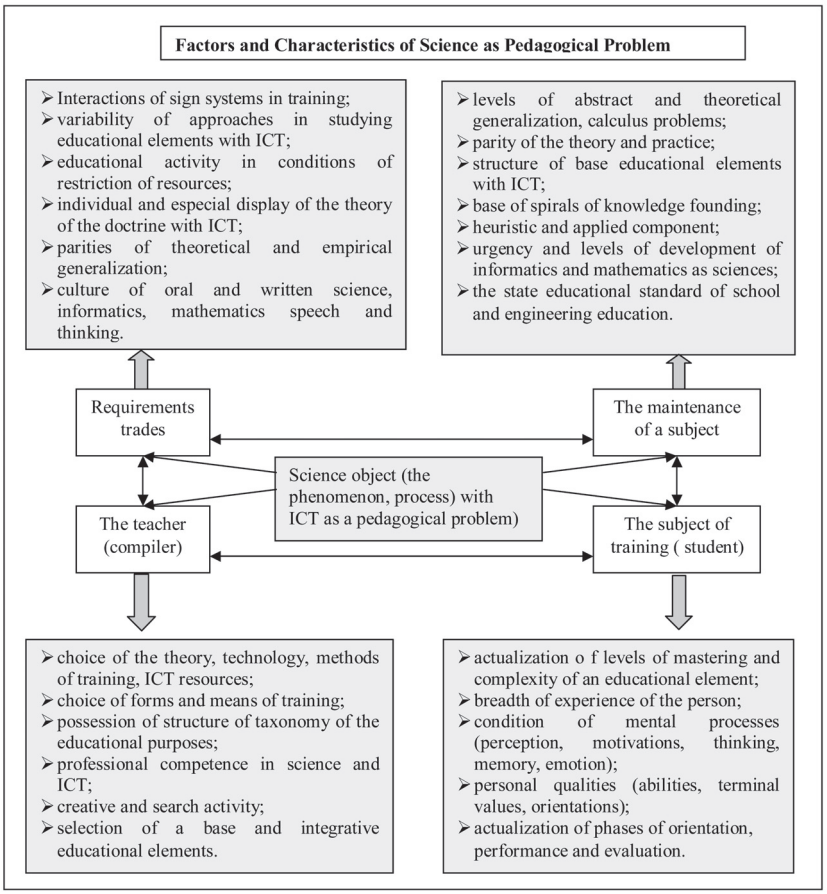


Fig.4. Factors and characteristics of science as pedagogical problem

with using of random numbers. There are used proceeding from formulated conditions the generated initial code of programming module of problem decision;

5. Realization of monitoring of students design activity from the point of view as teacher, and students. The main purpose of process analysis is the performance by students of project work and formation of further strategy of current design activity realization;

6. Realization of dialogue between students and the teacher in the form of a forum within of each project activity that essentially raises clearness of discussed problem borders in forums, for the purpose of problem allocation of areas and their further decision. *(Fig.5).*

On the base of development network and Internet technologies in educational process there is almost completely unresolved a problem of ICT mobilization for the purpose of small resources of information using. Practically at all stages of educational process realization (classroom activity without dependence from possibility of their carrying out in a display class, in house conditions, library, in the open air etc.) the requirement for integration of subject and information knowledge is obvious. The given problem reflects the essence of ICT development designated above the second direction for today, consisting in necessity of ICT transition from the level of local user on mobile level of an information technology realization.

Now practically within of small resources of information there is no possibility for monitoring of students educational activity, not to mention of design activity realization. If to track all available achievements on ICT mobilization for today it is possible to allocate only one class of small resources of information as graphic calculators which are rational for using in educational process with restriction of a scope within of reception and visualization decisions of necessary educational problems. Possibility of graphic calculators using in educational process speaks a primary orientation of given mobile devices from the point of view of hardware and program maintenance. However primary possibilities on using in educational process of other classes of representatives of small resources of information (cellular telephones, smart phones, communicators, a handheld computer etc.) are simply absent as those [19]. The matter is that the given mobile devices have initially been focused on especially applied problems a little connected with educational process that is for realization of telecommunication, access to the network the Internet as user and use of additional user functions, for example, application of the device as the camera, a player, an alarm clock etc.

On the same level with the essential lacks generated above modern REP, applied in high schools of the Russia, it is possible to allocate real *problem areas* which arise at realization of educational process with use of small means of information:

1. Practically a total absence of the concept and techniques using of small resources of information in educational process that directly reflects small volumes of studies support of similar mobile devices;

2. Primary absence of the software for small resources of information, directed on using of given devices in educational process in all its displays. This in itself is unacceptable as on the studies spent without attraction of display class, mobile devices are the unique alternative of personal computers replacement on realization of computing projects and problems;

3. Absence of direct application of small resources of information within of REP that is strange enough circumstance as the majority of modern mobile phones, smart phones and communicators give possibility of access to a network the Internet under HTTP report and some other reports with application of technology GPRS.

Now authors actively develop and approve the concept using of small resources of information in teaching mathematics [13, 14]. As a didactic material the methodical complex of graphic calculator CASIO ALGEBRA FX 2.0 PLUS using is developed. Thus various graphic calculators of Texas Instrument corporations and CASIO as one of the representative of small resources of information in the course of teacher training can be applied. Research includes the description of necessary methodical and

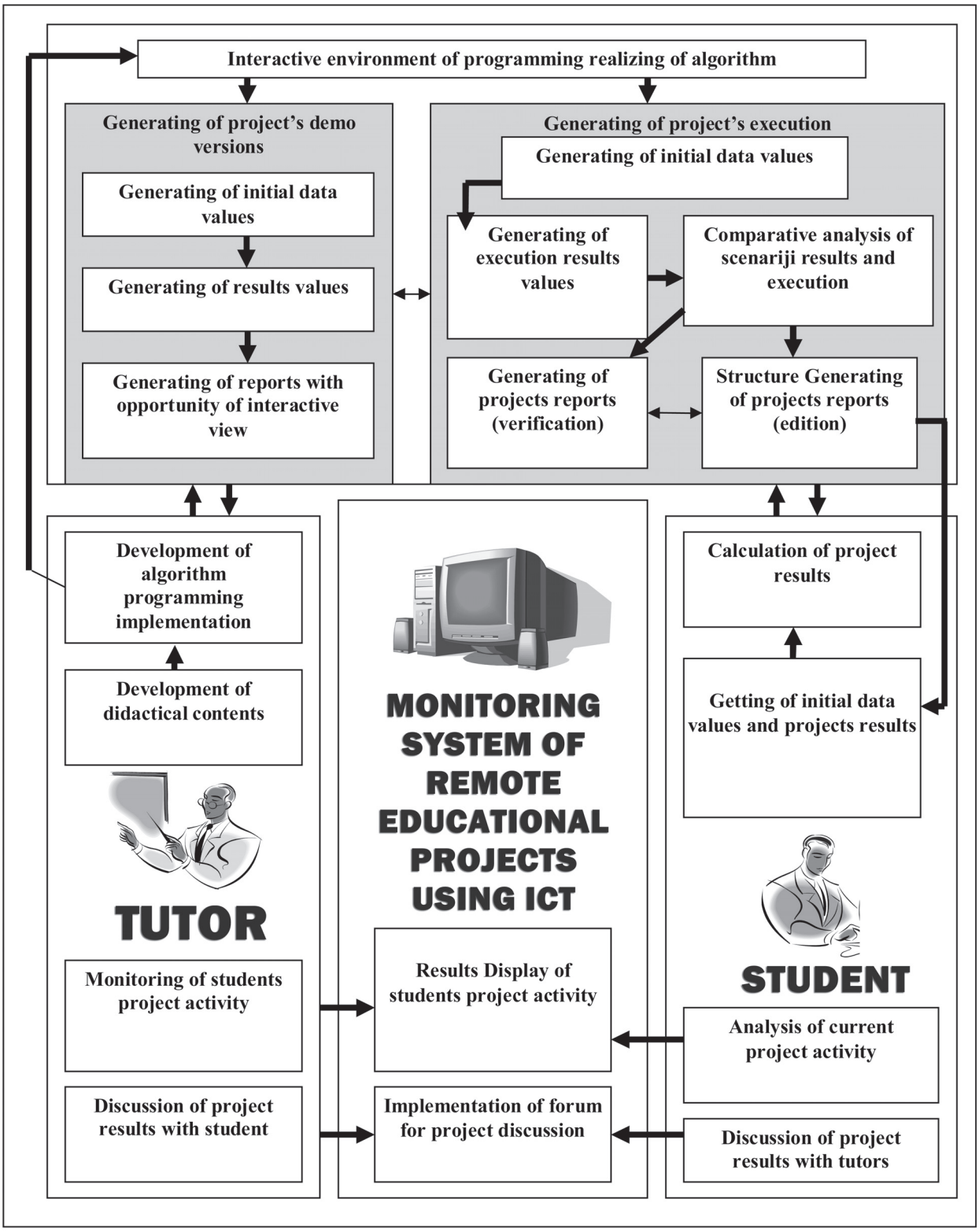


Fig. 5. The scheme of implementation of REP monitoring

didactic making various studies (a laboratory practical work, a practical training and an open classroom), the design problems focused on active using of educational activity realization.

The basic lack of graphic calculators as well as all representatives of small resources class of information is the total absence of interaction with Internet environment as directly or through of local networks. Thus also there is no a necessary software for work in Internet network (browser), therefore to unite graphic calculators in the uniform environment of remote training from the point of view of pupils access to educational projects for the purpose of subsequent monitoring of educational activity of students by the teacher is impossible. Unique possibility of graphic calculators using in educational process is presence of powerful

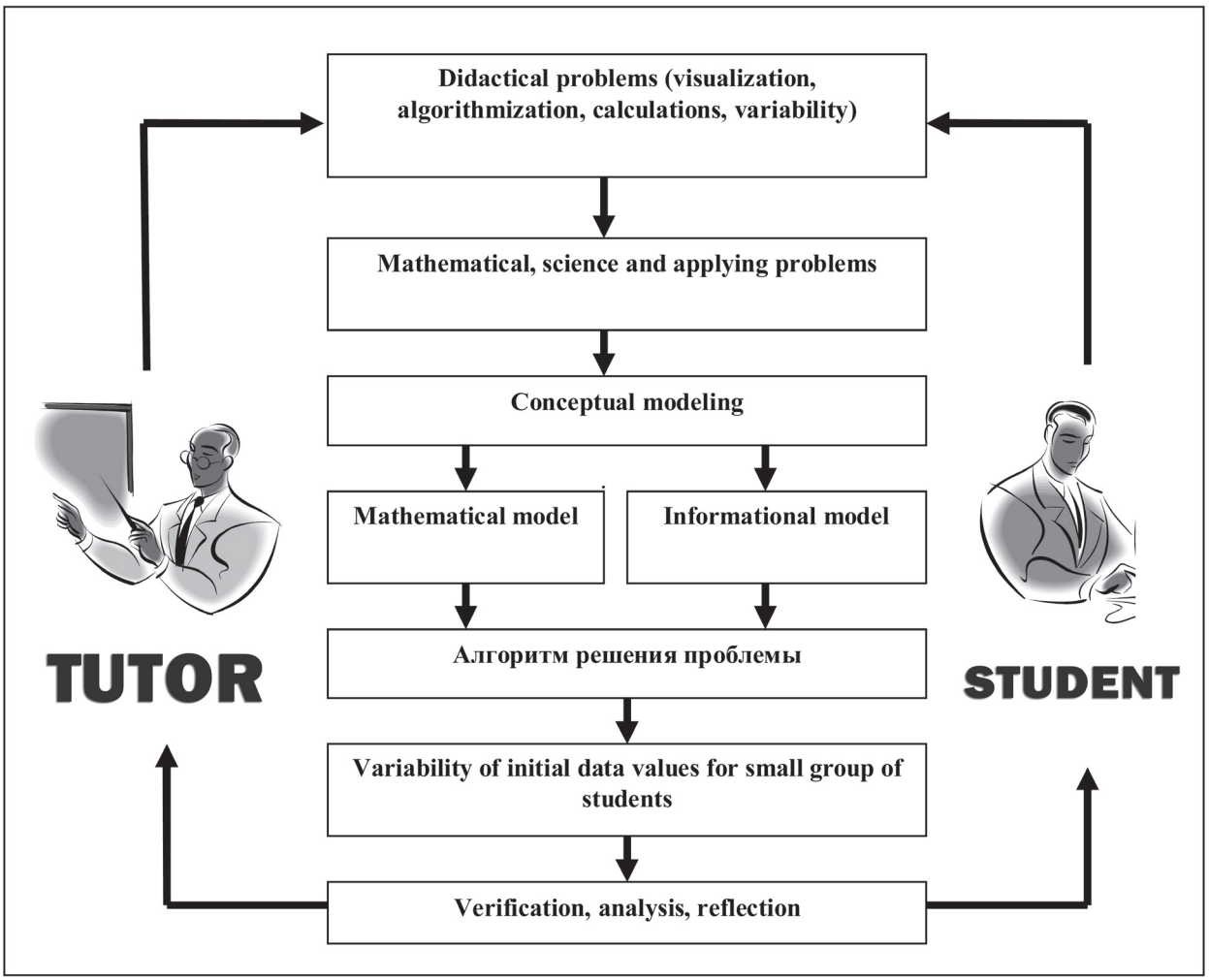


Fig. 6. The scheme of graphic calculator using in science learing

built in mathematical software realized on the level of computer mathematical systems and directed on realization and visualization of mathematical calculations connected with research of difficult phenomena and processes.

The technique of graphic calculator using offered by authors in the course of teacher training is characterized by following aspects (fig. 6):

1. Revealing and statement of the didactic problem consisting in necessity of using of graphic calculator on certain stages of problem decision connected with application of visualization, algorithmization and difficult computing procedures and variability of initial data values;

2. Allocation from didactic problem designated above, mathematical, science and applied problems and problems deducing on realization of difficult computing and logic operations, connected with visualization and also variability of initial data values;

3. Realization of conceptual, mathematical and information modeling for the decision of problems;

4. Working out of algorithm of problem decision on the basis of received mathematical and information models and its realization on programming level within of graphic environment of calculator;

5. Using of applied software developed on graphic calculator within of realization of task decision for the purpose of hypothesis formulation. After checking it on the basis of carrying out of comparative analysis of intermediate and total results in the course of a variation of initial data values. It is expedient to organize in this case some process of training in small groups of pupils that allows to revealing of various personal psychological features of students.

Authors on an example of developed laboratory work using of graphic calculator as integration tools of mathematical and information knowledge is offered at performance of numerical algorithms which essence consists in construction and visualization of iterative processes converging to required decision.

The technique of laboratory works using of communications principle in small groups is carried out on following stages:

1. The actualization of knowledge and the control of theoretical aspects and practical skills on using of graphic calculator;

2. The formulation of the name, the purpose and the plan of laboratory work carrying out;

3. The consideration of mathematical problem decision on an indicative example;

4. The distribution of students on small groups (on 3-4 persons) for the purpose of the various variants analysis of initial data;

5. Evident modeling and the decision of an offered mathematical problem with application of three numerical

methods on the basis of mathematical and information knowledge integration with using of graphic calculator;

6. The reflection and carrying out of comparative analysis of received results for the purpose of conclusions formulation and checking out of hypotheses;

7. The registration of laboratory work with subsequent representation to the teacher;

8. The presentation of results;

9. Individual interviews or verifying testing.

Diagnostic Procedure for Defining of Students Motivation and Calculation of Positive Shifts

Cognitive interest determines the activization of:

- achievement motives:
- presence of adequate result in practical activities;
- construction of mathematical and science model of process or the phenomenon;
- ability to consolidation (in thinking of the pupil and activity) the initial data for the decision of a problem;
- realization of a choice in methods and procedures of tasks decision;
- appearance of pupils insight in action research;
- ***social motives* are defined by the dialogue and interaction in small group:**
- a choice of a social role;
- social tests and search positive (internal and external) results of dialogue;
- expansion and development of activity in a direction of self-realization of the person;
- ***motives in action research* of pupils:**
- actualization of pupils insight;
- integration of thinking efforts of pupil;
- visual modeling in knowledge and process

The following table show the diagnostic procedure of student's motivation defining. (Tabl.1).

So we base on detailed structure of student's interests components, which consists from three area of characteristics: A – motivation of results achievement, R – motivation of self-realization, E – motivation of thinking efforts. Based on this position we define the *interests of students (I)* as vector (oriented) psychological category:

$$\rightarrow \rightarrow \rightarrow \rightarrow$$
$$\mathbf{I = A + R + E}$$

All of this characteristics should be actualized by special pedagogical instruments, actions, resources according to educational aims using ICT.

The model and the evaluation of a "resource lesson with ICT"

We try to use methodological ideas of problem solving, visual modeling, work in small groups, humanizing of science and mathematics education with ICT:

- *setting of the productive science problem with mathematics and informatics decision* (actualization of science, informatics and mathematics knowledge of the last years on the basis of integration; participation in discussion and statement of educational tasks; construction of science, informatics and mathematical model of process or the phenomenon; ability to consolidation (in thinking of the pupil and activity) the initial data for the decision of the problem);
- *educational activity of pupils on high level of complexity* (quasi-research activity of pupils aimed at analysis of results and search of new patterns of relationships; search experiment using numerical methods and computing procedures, diagnostics of information dynamics of parameters; monitoring

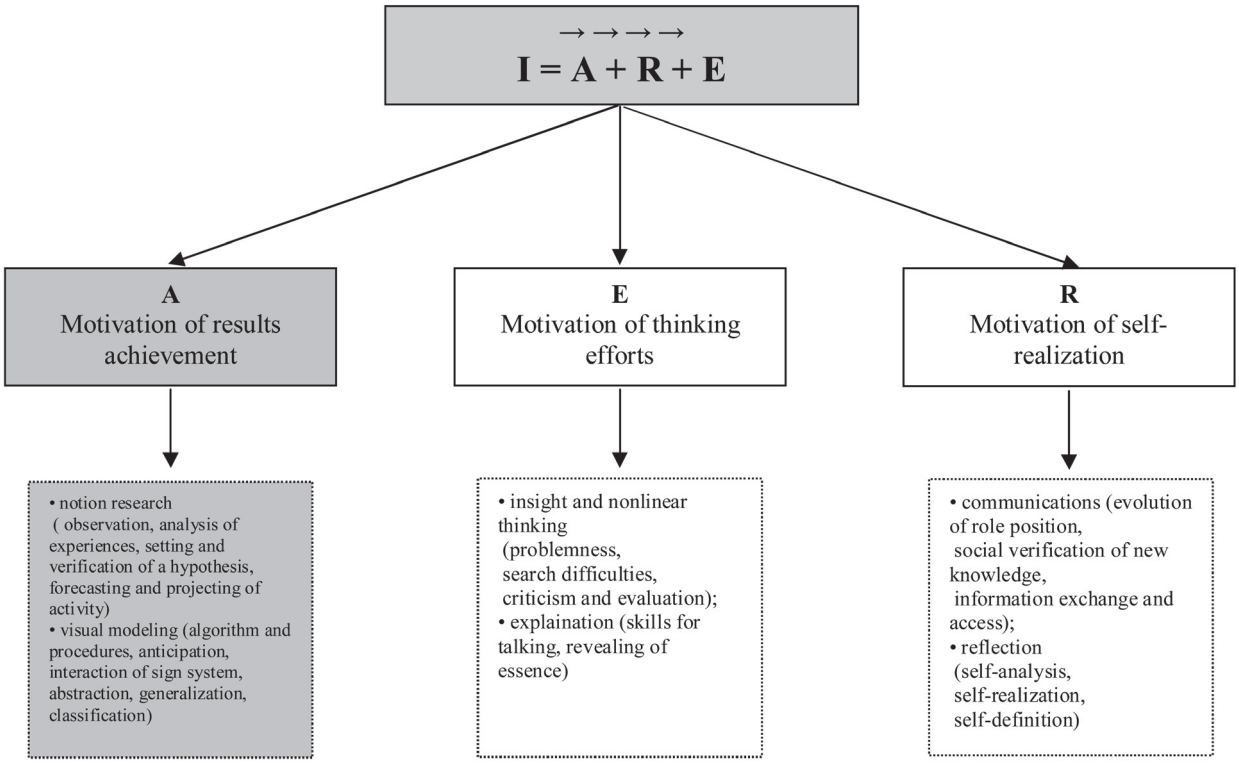


Fig.7. Characteristics of Components of Student's Interests

Tabl.1

Kind	Characteristic	Criteria	Technique of measurement	Measuring instruments
1. Motivations of achievement of results and an estimation of a level of claims	Define the stability of motives of aspiration to success and escape the failures on the basis of expansion of knowledge and interests. Estimates a degree of difficulty of the purposes which the person puts before itself	Presence of adequate result in practical (experimental) activity, –construction of mathematical model of physical process or the phenomenon, –ability to consolidation (in thinking and activity of pupils) the initial data for the decision of a problem (physical or mathematical), –realization of a choice in methods and procedures of tasks decision, -insight in action research	The test consists of lines of the statements concerning the separate sides of character, and also opinions and feelings concerning some vital situations. In the second test on the end of process of problem's decision the question naira directed on studying of internal both external motives and estimating a level of person's claims is offered to the pupils. It is spent 2 times(the beginning–the end	Updating of a test – questionnaire of A. Mehrabian (TMD in M.S.Magomed-Efimova's edition), V.K.Gerbacheskii's questionnaire (St.-Petersburg, 1990)
2. Motivation of self-realization of the person	Social motives are static zed by dialogue and interaction in small group	–a choice of a social role, – social tests and search positive (internal and external) results of dialogue, – expansion and development of activity in a direction of self-realization of the person	The version of sociometric Moreno's method is used. The principle of an estimation is put in a basis by each pupil's degree of sympathies-antipathies to each of the schoolmates by means of a polar numerical scale – Sociometric. It is spent 2 times	Sociometric tests are at studying system of interpersonal mutual relation of pupils (E.G.Zavertkina, S.V.Shvetsona, 2001)
3. Motivations of integration of thinking efforts	Enrichment of interests, emotional tone, intensity in development of resource and thinking activity in interaction of physics and mathematics	– Mental activity of the pupils in action research on the base of integration of physics and mathematics, –increase of interests to learning physics and mathematics, - insight and nonlinear thinking	The examinee independently estimates the condition on a 7-mark scale (interests, an emotional tone, a pressure, comfortable psychological activity). It can be spent in group and it is designed for repeated inspection. It is spent 2 times	The modified technique the DIGNITY (Doskin V.A.,Lavrent'eva N.A.) by a principle of polar structures of C.Osgud

and correctional interaction of obtained results, search of integrative knowledge and prospect of development; skills of visual modeling and estimation of real processes);

- *efficiency of using resources (material, materialized, ideal) for activization of cognitive processes and social interaction* (presence of adequate results in practical activities; joint analysis, information interchange, presentation of results; visual modeling in educational activity; reflection and internal plan of pupils action);
- *the organization of work in small groups* (distribution and the choice of social roles, planning, forecasting, acceptance of decisions, selection of the data and modeling, registration of results; social tests and search positive (internal and external) results of dialogue; expansion and development of activity in the direction of self-realization of the person).

As the result of such approach on organization of learning process for students in engineering universities we introduce the notion of " *resource lesson with ICT*" as the form of teachers and students activity for two subjects in one lesson on the ICT -base, so we define the "resource" as a necessary volume of the educational information in science (mathematics) sufficient for successful development of pupils' proficiency of in mathematics (science) according to educational aims, integration of subjects on the ICT-base and following characteristics:

- equal volume and complexity of subjects material (science, informatics and mathematics knowledge);
- setting of subjects aims (scientific, informatics and mathematical);
- setting of science and real problem with using of ICT and mathematical resource (algorithms, countable, logical, sign-symbolical, modeling and so on);
- computing and science experiment;
- social activity of pupils and work in small groups;
- preliminary procedure of actualization of science, informatics and mathematics knowledge;
- teachers manage the learning process of students together.

The educational aims of "resource lessons" are the investigation 2-3 engineering tasks with ICT in integration of science, informatics and mathematics using visual modeling technology across the series of models(concep-

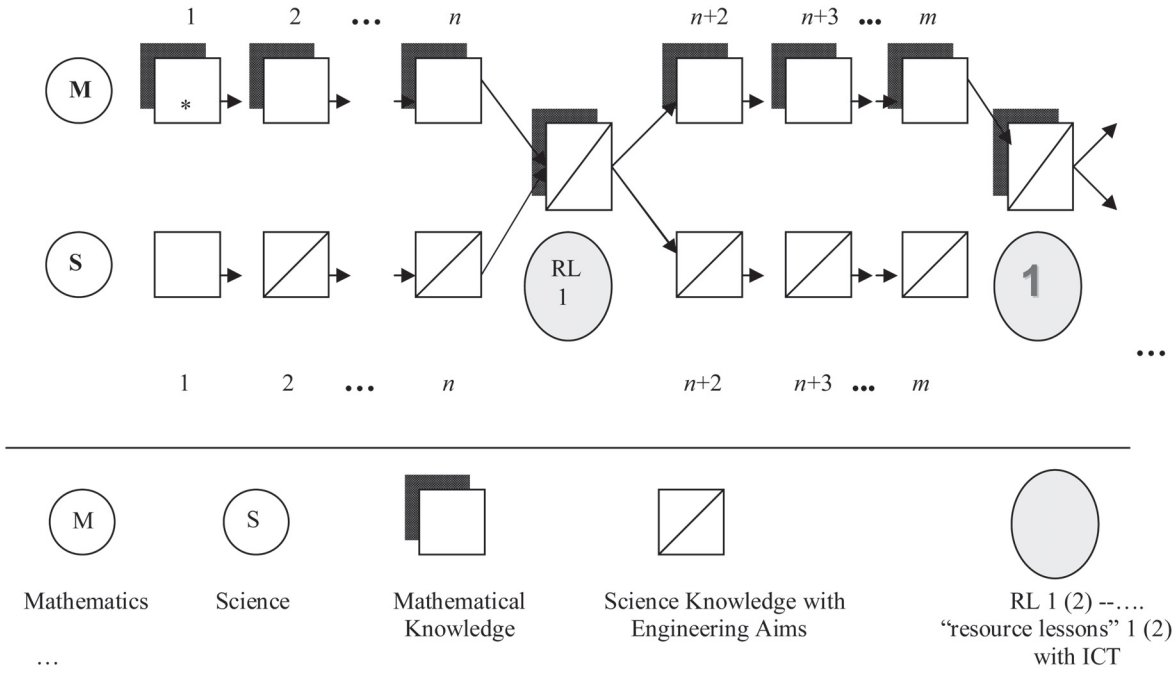


Fig..8. Dynamics of resource interactions

tual, science, informatics, mathematical). The frequency of resource lessons in semester is 5-6 lessons using the competence base education, scientific thinking and works in small group of students. The dynamics of procedure using the "resource lessons" is on the next Fig.8:

To our minds, one way to deal with the specified problems is to realize technology of visual modeling and conduct "resource lessons "at which the interrelation of learning material on science, informatics and mathematics is revealed to its full and individual activity of pupils grows.

Stages Description of Projecting Procedure of "Resource Lesson with ICT"

- The comparative analysis of curriculums in science, informatics and mathematics has been carried out: chronology of topics, allocation of topics with the resource, interactions, construction of structure of interrelations and their orientation, terminological coordination, bank of modeling situations.
- The analysis of engineering experience' working patterns on science, informatics and mathematics using with ICT" in the world practice according to the criteria Project's aims has been executed; the project of the innovative contents of the inter-subject interaction has been constructed.
- The future engineer have filled in the questionnaire on methods of science, informatics and mathematics coordination, the students have been interviewed and asked to fill in the questionnaire, The analysis of pedagogical experience of in inter-subject connections in science, informatics and mathematics (the methods of conducting research, the bibliography on the problem, unity of teaching and methods of' activization of student's cognitive activity of, impact of activization of the mathematical (science) and informatics resource on changes in motivation, thinking and personal development) have been carried out.
- Psychological diagnostics and sample tests in experimental and reference forms have been carried out.
- Diagrams reflecting coordination of topics and resources in certain sections of science, informatics and mathematics are constructed.
- Scripts of some resource lessons have been made and trial lessons in University's classroom form based on the innovative methods have been carried out.
- The resource lesson with ICT and video data have been analyzed. A videoclip and comments to it have been made.

5. Good Practice Using ICT (Graphic calculator, Maple) on "Resource Lesson"

The analysis of curriculum on physics and mathematics have shown the mismatch of sections learning and have defined the "resource lesson" and "coordination graph" technologies constructions. We look on two lessons in Russian schools concern with " resource lesson" methodology. Testing applying to more than 1000 pupils of secondary schools have shown strong influence the volume of mathematics in science on pupils motivation. At the same time it will be grown the level of "scientific thinking" and research activity of pupils.

First one is the title " *Fall of the body*" for 10 class of secondary school (integration of ICT, physics and mathematics) using the graphic calculator.

Purposes and problems:

- Using Newton Second Law to research of the real physical processes (the building physical, informatics and mathematical models, structures acting power , procedures and mathematical dependencies);
- Use the numerical methods for the decision of the physical problem with

Students Action Research Activity with ICT

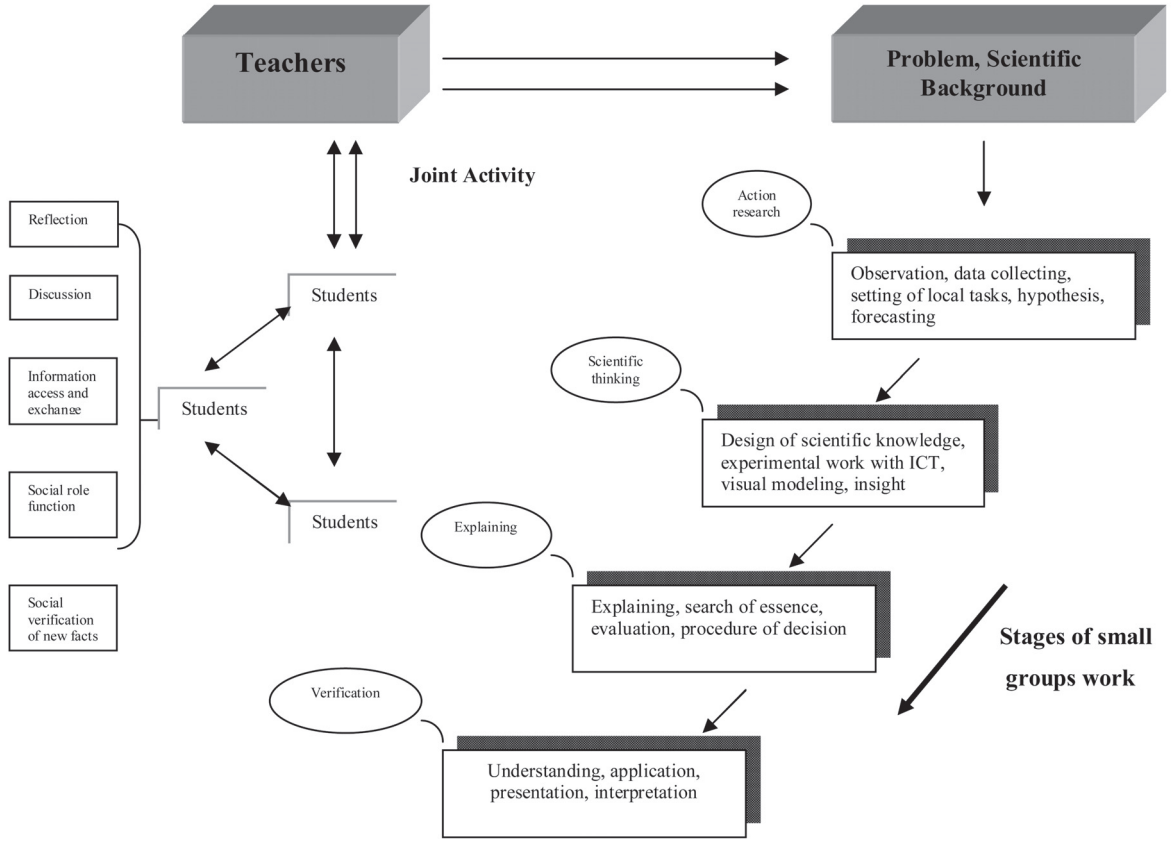


Fig.9

ICT –graphic calculator (the method iteration, approximations, derived to differential relations);

- Use the graphic calculator for complex current calculations and visualizations stages of decision of the physical problem ;
- Substantial interaction of informative and physical resources (visual modeling, structure, levels, dynamics, forms, efficiency) using mathematical tools;
- Motivation to physics learning using informatics and mathematics for personal development of pupils.

Setting of the problem:

The body by the mass 70 kgs falls with the big height. The power of the air resistance is finding by the equation $F_{re} = Av + Bv^3$, where factors A and B are defined of the body size. Let these factors are the following values: $A = 5H \cdot s/m$ and $B = 10^{-2}\ H \cdot s^3/m^3$. We must to find the velocity depending on time, passed after begin falls. Trace the graphics v(t) and s(t).

Organization Work in Small Groups:

Features

1. Dialogue, discussions and criticism in behavior and thinking of pupils
2. The analysis, information interchange, presentation of physical and mathematical results
3. Integration of graphic calculator using and estimated and algorithmically activity of pupils

Procedure

Work in small groups with the purpose of self-determination, self-realization and activization of independent cognitive and creative activity of pupils (groups on 5-6 pupils are united on personal sympathies and interests with possible rotation of structure and distribution of functions and roles in group)**:** (Fig.11, Fig.12).

We should use in this procedure the method of sequential approximation for calculation the values of *v(t)* and *s(t)* as functions from time. The students can change the values of *A,B, m, t* for view (by using the graphic calculator opportunities) on dynamics of process. They can answer on questions:

Is a function *v(t)* monotone?

Can you find the time of body landing?

What happened with time landing, velocity landing if the body will have the different initial velocity?

How can you see that happened with velocity and time landing if the mass will be different?

and so on.

The students can fill the table of values , view the graphics, try to find the analytical decision of the problem.

Activity of pupils:

- Distribution of social roles in small group, an individualization of educational activity (planning, forecasting, acceptance of decisions, selection of the data and modeling, managing of graphic

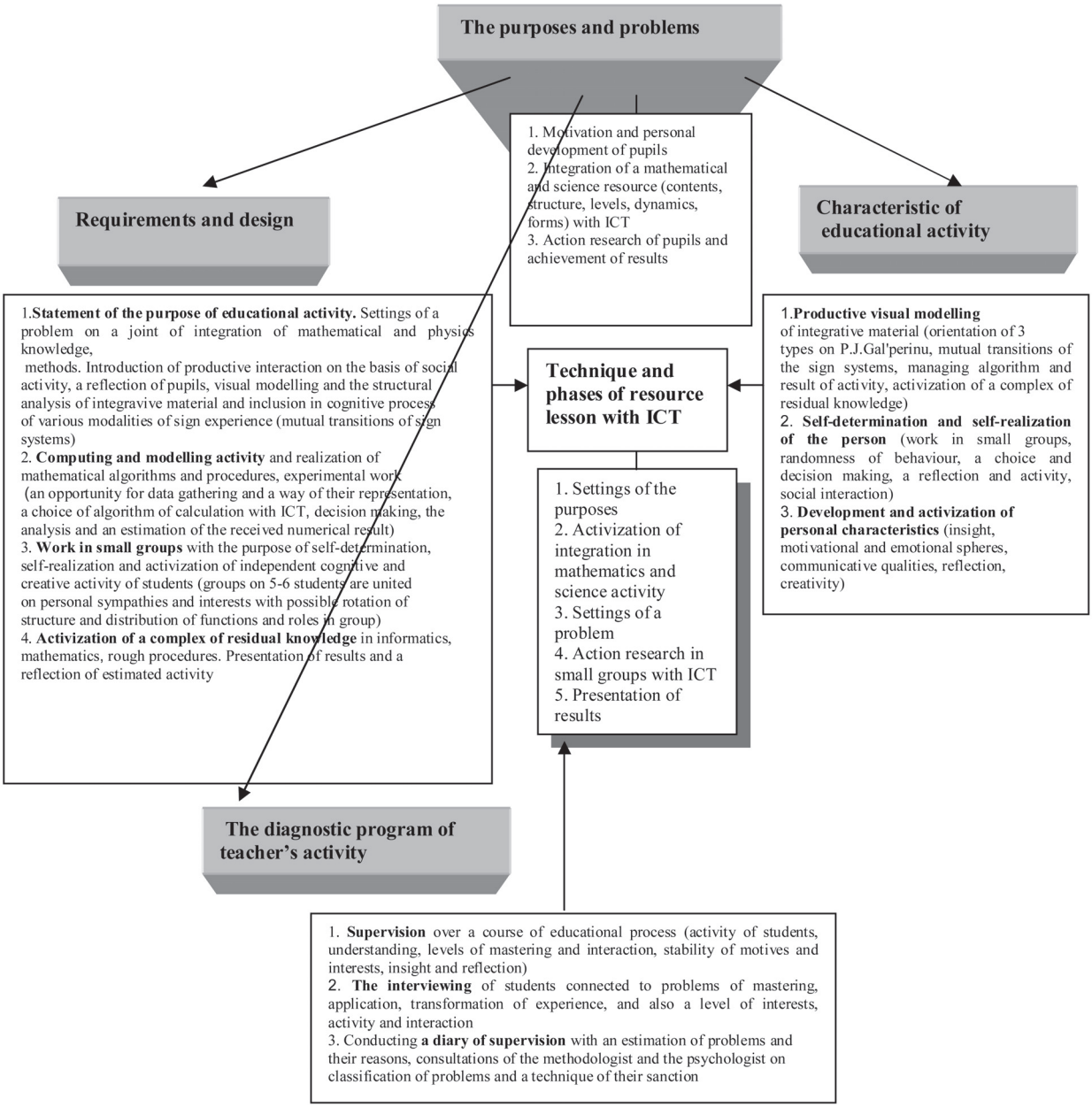


Fig.10. TECHNOLOGY and Phases of Resource Lesson with ICT for Action Research

calculator using, registration of results;

- Presentation of research results in small groups and reflection

Within of laboratory work with the decision of following design problems from calculus [13, 20] is carried out:

1. The calculation of minimum numbers values on approach to a limit of numerical sequences

$$x_n = \frac{a_2 n^2 + a_1 n + a_0}{b_2 n^2 + b_1 n + b_0}$$

(for $\varepsilon > 0 \quad a_2 \neq 0 \quad b_2 \neq 0$, $\left| x_n - \frac{a_2}{b_2} \right| < \varepsilon$) with using methods of a gold proportion, Fibonacci, a dichotomy and their comparative analysis (section *«Limits and a continuity»*) [13];

2. Decisions of algebraic and transcendental equations with using of dichotomy method, combined method of chords and tangents (Newton), iterations method and their comparative analysis (section *"Differential calculus"*);

3. Calculations of certain integrals values under formulas of average rectangles, trapezes, parabolic trapezes (Simpson) and their comparative analysis (section *"Integral calculus"*);

4. Decisions of ordinary differential equations of first order with using of Euler method, Runge-Kutta of the second, fourth usages of accuracy and their comparative analysis (section *«Differential equations»*).

Further realization of unique integration of above-stated tendencies of ICT development within of educational activity thanks to developed information system of REP monitoring of students in secondary and higher school using an access to given environment is offered. Thus interactive activity is possible as from personal computers through Internet global network and from certain representa-

Fig.11

Physical Model

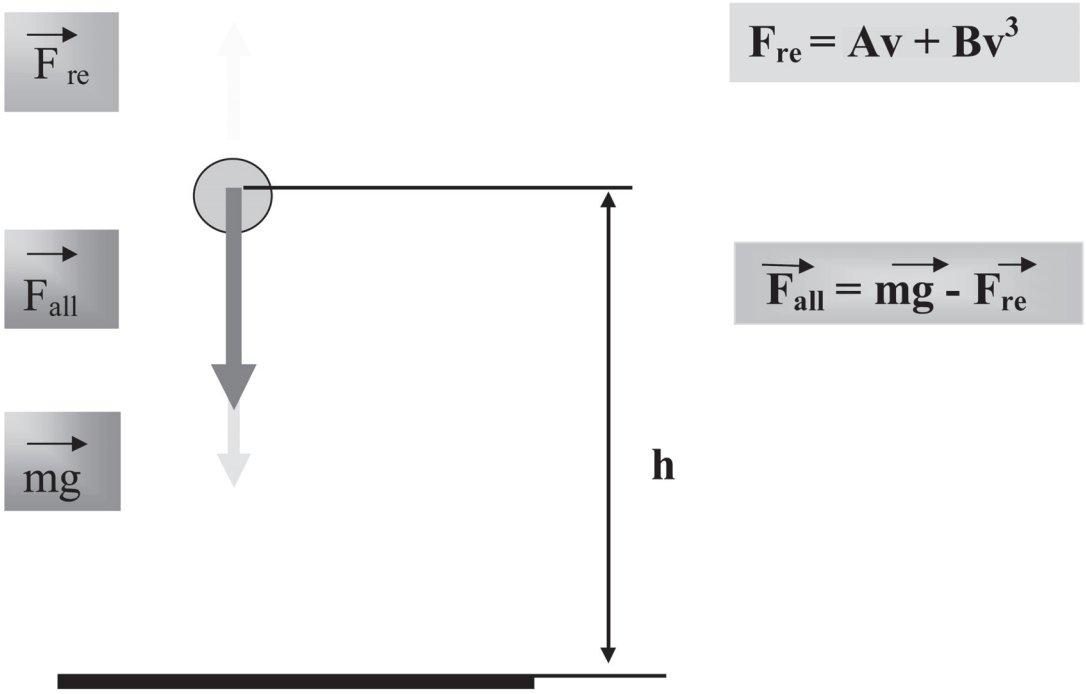
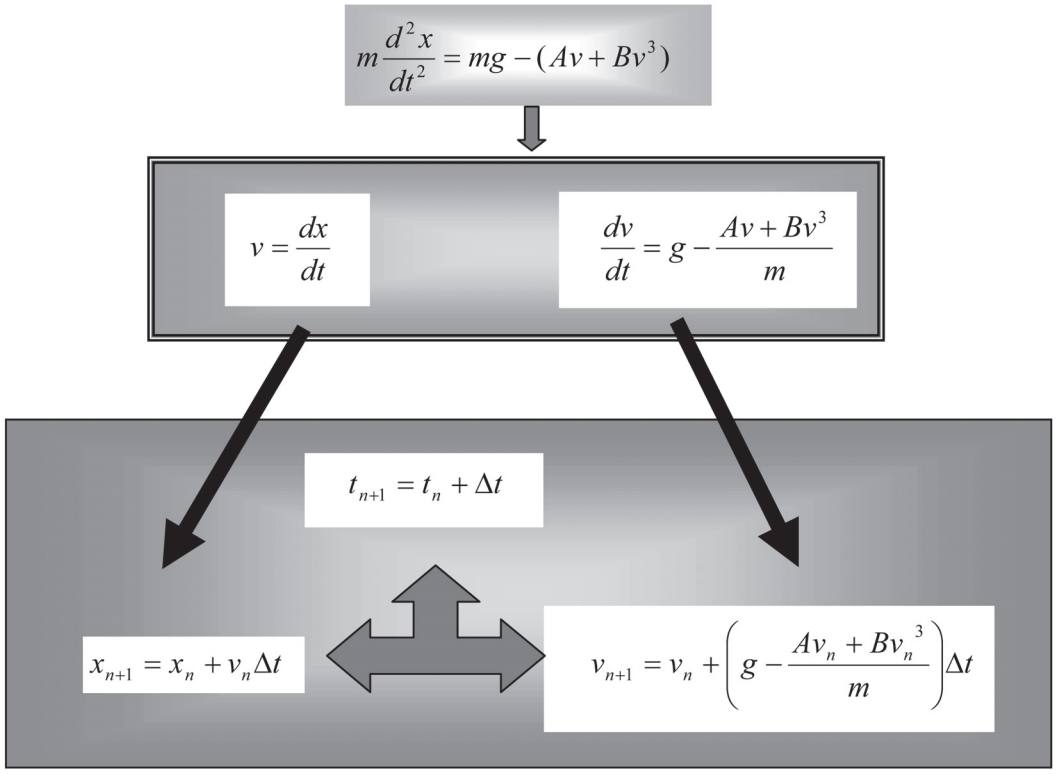


Fig.12

Mathematical Model



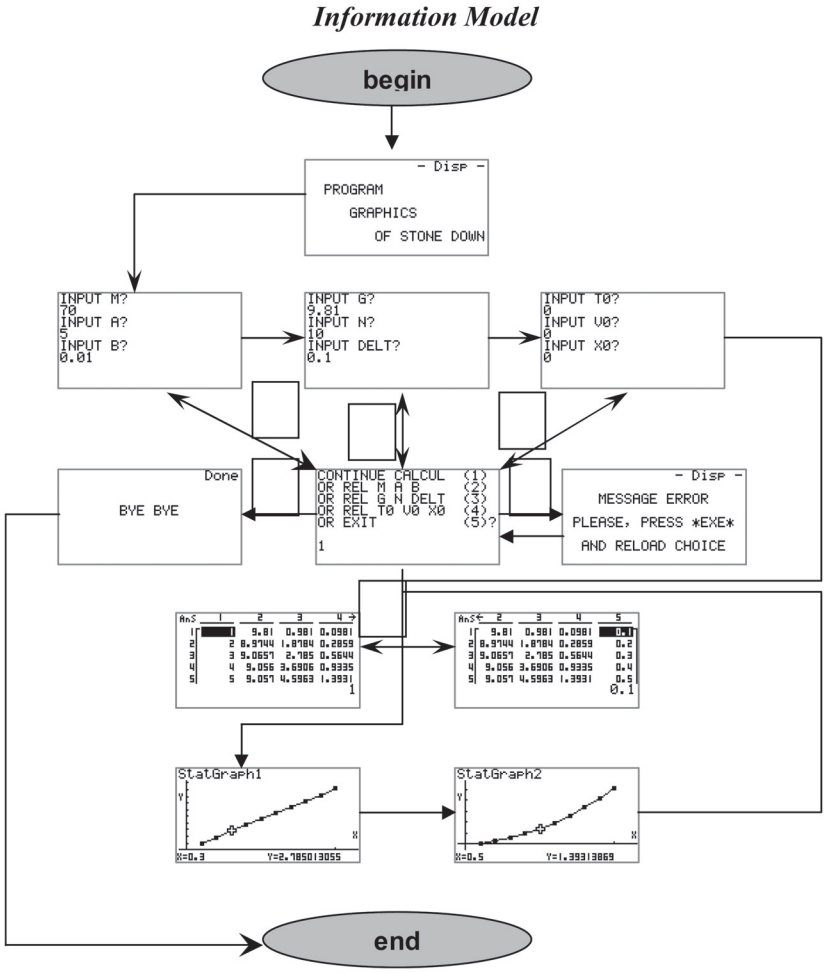


Fig.13. Information Model

tives of small resources of information (mobile phones, smart phones, коммуникаторы) on the presence of GPRS technology supposing of HTTP report. It finally will allow to realizing the uniform environment of remote training of students in high schools, uniting all participants of educational process without dependence as from the presence of display class and geographical position of educational process participants on realization of independent activity and monitoring of students educational activity by the teacher.

6. Conclusions and suggestions

The analysis of these results made us feel confident that the hypothesis concerning the opportunity to increase motivation in learning of science (mathematics) by incorporating into science (mathematics) lessons of suitable mathematics (science) material is consistent and logical. It can be achieved by means of development of "resource lessons" and activization of cognitive activity of engineering students by visual modeling and group work activity. The conducted research has shown the importance of the chosen topic and has partially confirmed the put forward hypothesis about the significance of the integrated approach to interaction of science and mathematics with ICT in engineering education. Research of the innovative approach in visual modeling of science, informatics and mathematical processes, activation of motivational and cognitive processes have promoted positive changes in personal development and successful mastering (learning) of teaching material. Resource lessons with ICT as basic form of realization of interaction of science, informatics and mathematics has shown its efficiency and opportunity for further research. It is recommended to develop the cycles of resource lessons with ICT in learning of science and mathematics at University and to carry out a detailed analysis and feasibility of the technological innovations.

On the basis of the model and the method of research we have worked out ideas on the series of "resource lessons" with ICT for engineering students (also using computer mathematical system: Maple, MathCad, Mathematica and so on) on the laboratory work on science or lessons in mathematics or science including remote E-learning environment. Together with teachers and teacher educators we have to design more lessons, to carry out those lessons in classrooms and to analyze the lessons and the knowledge of the students. We also want to design lesson activities in which engineering students can learn by means of computers as a learning tool more scientific problems. The experiences are very promising and we like to investigate the use of simulations and computer based laboratory work in relation with "resource lessons" in mathematics and science.

In the conclusion it is necessary to notice that unique possibility of creation of high-grade uniform environment

Tabl.2

GROUP 1	GROUP 2	GROUP 3
INPUT M? 70 INPUT A? 5 INPUT B? 0.01	INPUT G? 9.81 INPUT N? 10 INPUT DELT? 0.1	INPUT T0? 0 INPUT V0? 0 INPUT X0? 0

of remote training of students in high schools is organized educational process on the basis of dynamic level realization of settlement educational projects with access possibility to the information through local and global networks and using of small resources of information in forms of cellular telephones, smart phones and communicators.

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