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SYSTEM FOR THE ORGANIZATION OF MULTI-LEVEL INDEPENDENT WORK AIMED AT MODERN MASTERING OF CHEMISTRY IN VOCATIONAL EDUCATION

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Abstract. *One of the most topical education tasks today is to provide an individual with a systematic self-managed learning possibility, through activating his/her reasoning potential and developing independent research work skills. The article deals with a system model of multi-level independent work organization concentrated on student's learning and research activity in close interaction with the chemistry subject's content. Being appropriate for training of modern seafaring (engineering) specialists and substantial for a student, it facilitates implementation of an independent, self-managed learning concept. The structural concept of the proposed model is based on a cooperation-oriented student's practical and research activity. Alternately changing the structure elements it promotes: (i) development of the comprehension of the chemistry knowledge application and transformation; facilitates (ii) mastering of integrative knowledge and skills; improves (iii) chemistry learning productivity and scientific comprehension; strengthens (iv) self-regulated activity experience, thus ensuring the perfection of research activity competencies.*
Key words: *self-managed/independent learning, complexity proportionality principle, homework, group work, research work, research competence.*

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Introduction

Changes in Europe in the higher education system, including also Latvia, are connected with advancement towards harmonization of the European Area of Higher Education and endeavours to assess systematically the achieved results, to consider aspects to be resolved urgently and to advance in the process for the development of generally comparable and compatible area till 2010 (Bologna Declaration, 1999).

The London Communiqué (2007) of the Ministers of Education of Bologna process member states sets out the following main tasks:

i) To prepare students for an active life as citizens in a democratic society.
ii) To prepare students for their future career and to ensure possibilities for their individual growth.
iii) To create a broad and modern base of knowledge and to facilitate research and innovations.

One of the essential tasks to be resolved during the higher education harmonization process is transition to student-oriented learning, rather than teaching where the teaching staffs is dominating (London Communiqué, 2007).

The fast growing level of science and technology and experts' forecasts that the development of future society to a great extend will depend on the education in natural sciences and technology caused the European Commission (2005) to take a decision to increase the proportion of natural sciences and technology education in higher education establishments. Till 2010 it is envisaged to increase the number of students of mathematics, sciences and technologies to 15%, thus the development of Europe is associated

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with the formation of scientifically and science skills educated society. This intention can be put into practice only through ensuring qualitative and effective education on each stage.

The analysis of situation with regard to the subjects of sciences on the school level is rather alarming. Researches made by TIMSS and OECD, as well as by individual scientists during last decades (have) discovered a correlation between the pupil's achievements in science subjects and his/her ability to link the mastered knowledge with the surrounding world and everyday life experience; to apply them in problem solution and decision making. Unfortunately for pupils in many countries this ability is insufficiently developed and trained. Besides, the researches show that chemistry is the least interesting and most difficult subject in school (Guzejev, 2001; Stäudel, 2004; Jenkins, 2005; Gedrovics, Jeronena, Kuusela, Warenborn, 2006).

The reforms in the chemistry education in many countries of the world are going on already for several decades. The harmonization and perfection of education curricula on all stages of its mastering are proceeding according to the recommendations of chemistry education specialists. However despite all this the "old range of problems" in chemistry teaching still exists and has not lost its topicality. Besides, the problems are similar both on school and high school level, because it is about the accessibility, understanding and comprehension of the content of subject both by pupils and students (Johnstone, 1997; 2000a; 2000b; Tsaparlis, 2002; Taber, 2002; Justi, Gilbert, 2003; Bucat, 2004; De Jong, 2005; Mbojogu, Reid, 2006).

Thus development of the chemistry subject content and teaching/learning methodology satisfying modern requirements and education quality requirements is a rather urgent matter.

Methodology of Research

Essential issues to be solved for the development of a harmonised and unified European Union education area is transition to a student-oriented learning (Bologna Declaration, 1999) and creation of learning environment where an individual can acquire a systematic independent learning experience, comprehension to link the mastered knowledge with the surrounding world and every-day life experience, to apply them in problem solving and reasoning, reaching a quality that would provide him/her with a targeted lifelong learning (UNESCO, 2000; UNESCO, 2001).

For the development of independent work organization model for mastering chemistry in vocational education that would comply with the modern education trends and requirements, and for the testing of its efficiency in practice, the following research methods were used: analyses of pedagogic and psychology literature, inquiry method (with and without involvement of experts), questionnaires, testing, experiment, statistical analyses of empirical research data, applying statistical data processing set SPSS version 13.0. The research structure is as follows:

1. The analyses of pedagogic literature allows to conclude what in modern didactics is understood by a notion self - regulated learning and what methodical solutions are applicable in mastering chemistry. The analysis of cognitive psychology literature clarifies and substantiates the possible specific chemistry learning provisions.
2. The pedagogic reality – possibilities to master independent learning experience during the LMA study process, students' motivation and interest in learning, their learning needs and interests - has been analysed in the following empiric research succession:
    - The inquiry carried out by the expert group of the Latvian Marine Academy (LMA) Quality in the autumn of 2002 with the objective to determine guidelines for the improvement and perfections in the LMA activity in future.
    - Joining of 'emotional and rational' spheres in the content of chemistry subject serves as a precondition for the implementation of the didactic process of independent learning. The mechanism for joining these spheres is revealed by the analyses of the results of research carried out in January 2003 on the correction of chemistry subject content, its integration and coordination in professional subjects' modules.
    - Based on the cognitions resulting from the examination of scientific literature and results of analyses of researches carried out within the LMA, a model for a multi-level

independent work organization system in chemistry was developed, and its efficiency was tested experimentally in the Latvian Maritime Academy (LMA MS) and high school during the period from 2003 (autumn) till 2007 (spring).

In the mastering the chemistry content the application of multi-level independent work organization model facilitates development and improvement of students' research competency. The procedural essence of competence is rooted in the unceasing development of abilities, through the improvement of students' experience and expansion of the possibilities to gain this experience, by carrying out practical and research activity both individually and in groups, as a result expressing their capacity to transform and apply the knowledge on the subject and practical activities, to voice conclusions based on their scientific comprehension of the processes in the surrounding world. For the credibility of the dynamics and consolidation of the research activity competencies the students' performance in the learning process was compared with the performance in the solution of complex tasks (at the end of semesters 1 and 2) and at the professional qualification exam (at the end of semester 8).

- The experts' method was used for the complex task validity. The experts attracted were specialists of chemistry, physics and ships' mechanics (6 expert's altogether).
- The results of experimental research have been processed and analysed by the help of the statistics processing and analyses set SPSS, version 13.0, which includes:
  - i) Descriptive Statistics Methods, namely method for the analyses of frequency and central tendency indexes.
  - ii) Inferential Statistics Methods, namely Compare means, Correlation and Regression analyses methods.
  - iii) Error Bar method.

Results of Research

Self-managed learning aspect in the teaching/learning process organization

The conclusion voiced by a representative of modern pedagogy – Danish pedagogue Steve Larsen - that no teacher can teach anybody anything, but he/she can create situations and organize work in such a way that pupils can learn themselves (Kjaergard, Martineniene, 1996), stresses the first aspect of logical argument for self-managed learning. Already in 1873 the British philosopher Herbert Spenser referred to it as an ideal, when writing that the driving force of human progress is only self-learning, and in order to reach the best results each intellect must develop in this way.

On the eve of the 21st century this conclusion is included in UNESCO documents as a task of education in the 21st century. Namely, during the learning process it is necessary to create an effective, qualitative and stimulating environment, where an individual gains the experience of self-regulated actions that would serve him/her as a basis for self-regulated learning aimed at lifelong education quality improvement (UNESCO, 1998; UNESCO, 2000).

In many pedagogical theories the notion 'independence' includes high pedagogy ideals to aspire to. Its development should unequivocally be linked to independent activity (Badmajev, 2000). Thus, the positive ideal for "himself/herself", namely how and when the individual wishes or is doing something at a relatively high level of independence and self-direction, keeping aloof from "strange management" was revealed in discussions about independent study or self-regulated learning ((Zimmermann, 1989; Kraft, 1999; Gage, Berliner, 1998).

Independent learning is related to the so-called "metacognitive consciousness" (Beck, 1991). It comprises a concept on an individual who wants to learn independently, learn himself/herself and his/her learning abilities, voices his/her problems, links new knowledge to the old ones, understands the meaning of the subject in life, plans, organizes and regulates his/her learning himself/herself, learns, through organizing, using learning strategies and techniques, evaluates the course of his/her learning (Rampillon, 1994). Actually it means that during the learning process the individual enriches himself/herself, by undertaking bigger responsibility for different decision making. Thus this type of learning requires from him/her broad competencies in the reflection, planning, placement and realization of

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study subject. Different knowledge, motivation and emotional components are very important for successful learning; essential is preliminary knowledge, regulation of learning problem solutions, autonomy experience and self-regulated performance confidence (Zimmermann, 1989; Zimmermann, Schunk, 2001; Friedrich, Mandl, 1995).

This learning concept is based on the understanding that learning is orientated to the construction process of subject's knowledge and skills (Barr & Tagg, 1995; Friedrich, Mandl, 1995; Lea, Stephenson & Troy 2003), which is based on his/her rational activities (Holckamp, 1995) as well as on self-control, motivation and will elements (Zimmermann, 1989; Zimmermann, & Schunk, 2001).

It does not mean that learning takes place without collaboration with other persons. To be able to learn the individual must receive information from outside, therefore learning simultaneously is regulated by the individual himself/herself and by other persons (Maslo, 2003). Within this process the individual performs independently one or more self-regulation measures/activities, for example, reads, participates in the group work, uses Internet or reflects the mastered information in writing. The participant of this learning process is able in different situations to transform both his/her knowledge and skills. The pedagogues in this case fulfils different roles, for instance, makes a dialogue with the learning process participants, provide them with learning materials, evaluates results and facilitates critical reasoning (Lieģiniece, 2002).

Thus self-managed learning actually is a subject (student)-oriented learning with a constructive view to learning course. During this process the individual constructs his/her knowledge and skills, "builds" them into his/her preliminary knowledge and thus is able to transform and apply them in a new complex situation. The basic feature of independent work is that by respecting differences of individual's cognitive abilities, he/she personally is granted a crucial possibility to make the choice. The result is monitored by the individual himself/herself. Thus during independent learning his/her mental and cognitive self-activity (in cognitive, metacognitive, voluntary and behaviour type) is developing. From the organizational aspect it requires a thorough preparation of students, thoughtful supervision and assessment of study process and results.

Research-based approach as a self-managed learning model for mastering chemistry content

The research-based approach to learning is one of self-managed learning models when the individual:

- Takes interest in the subject content himself/herself,
- learns new material through examples, faces alternative views, and drawbacks and shortcomings of the existing explanations, doubts about the credibility of conclusions;
- initially analyses the practice, then plans his/her research, researches, analyses, describes and interprets the obtained results, develops his/her theory, substantiates and states in clear form.

Research oriented learning means personal involvement of all students. And from the pedagogues – personal and professional readiness to collaborate with them, whereby borders are widened: as a direct experience and as its realization by students (Klarin, 1998).

Research type learning is the most suitable model in mastering chemistry because it relates to the specific character of chemistry science, namely, to investigate the properties of chemical substances and their transformations. Besides, the most significant structural element of the learning process in chemistry is a research based experiment. It serves the pupil or student both as the source of knowledge for getting new information and as a practical proof of theoretical knowledge (Christen, 1998; Heimann, 2003; Barke, Harch, 2001). As was pointed out by J. Mincenkov (2000) learning cognition in chemistry lessons differs little from that of research. Because in the science likewise during the learning process, understanding of the object (chemical substance, conditions, notions, etc.) being studied is continuously perfected and enlarged. Therefore the research type learning has a developing potential since it results from the independent value of research activities.

Thus in the chemistry mastering processes self-managed learning on the basis of research-oriented model might be implemented effectively, provided the subject;

- Accepts consciously that chemistry learning and research work problems are essential for him/her;
- Is motivated and willing to participate actively and influence his/her learning process during subject mastering.

It would promote development and strengthening of self-regulated and research work experience, through developing skill to apply and transform knowledge of chemistry, as well as facilitate scientific comprehension about processes in the surrounding world.

Stable preliminary knowledge, understanding of learning material and knowledge how to solve learning problems are essential for this learning approach.

Specific aspects of chemistry learning as factors affecting the quality of self-managed learning

Self-managed learning theory is closely related to teaching theories that are based on conclusions of cognitive psychology where an individual is regarded as the processor of information, but learning – as the process of information processing, representing interaction between the existing and new knowledge. Thus memory plays an important role in the learning process because these are close interrelated processes. Representatives of cognitive psychology, based on experimental and clinical researches, have developed several theoretical concepts on the functioning of memory. Important role in these processes is played by operative memory, which is fulfilling very manifold functions, namely:

1. Operative memory keeps the incoming information in depository or short-term memory depository. It uses it to develop understanding about this information and keeps in the focus of attention. Encodes and recalls information from the long-term memory. Fulfils the role of intermediary, which is manifested as general cognitive system, retaining important informative tasks during cognitive performance.
2. It is a functional component of cognition in solving different problems, in representation of mental activity, harmonization of objectives, activation of functioning of possible or necessary experiences or knowledge.
3. It is a temporary information depository system, which activates the retained information from the long-term memory, strengthening its application. Controls speed of memory and attention functions. (Gage, Berliner, 1998; Vorobjov, 1996; Baddeley, 1999).

Scientist A. Johnstone (1982; 1991; 1999) compares understanding and memorising of new information in chemistry lessons with a "synthesis" taking place in the operative memory depository, through interaction of the new information and information recalled from the long-term memory. The scientist points out that this process can proceed differently, namely:

- If it's has proceeded correctly then the memorised and encoded material can be recalled from the long-term memory and be used in repeated activities.
- If the understood material that has reached the long-term memory has been "wrong" or information interaction linking has been "damaged', the student faces misunderstandings, which are encoded in the long-term memory. It is very difficult to change them later, to recode and return. Because what we have accepted as useful and correct builds a carcass of stable memory concept. [This case is particularly risky regarding individuals with weakly expressed self-criticism or increased. inadequate confidence in his/her mental abilities. (Korobov, 2003)].
- The synthesis might also not occur because the student is unable to locate any link in the long-term memory that would connect the new information with information already existing there, and thus the new information is returned to the temporary information and forgotten.

It is nearly impossible to recall in memory also information or knowledge where previously it has been crammed" and not comprehended. Actually the "crammed" information is in the form of unconnected and unstructured information, so it does not serve as a link between the previously mastered and the new information, and thus it causes overloading of operative memory and burdens further procedure of cognitive processes (Bodner, 1991, Johnstone, El-Banna, 1986; Johnstone, 1999; Korobov, 2003).

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So, to be able to remember information it must be understood, comprehended and linked in a system. However, we must admit that too big and complicated volume of information causes incomprehension of learning material and unstable knowledge, thus affecting negatively the efficiency of functioning of operation memory and overloading students' and pupils' memory both in the chemistry lessons and test works and exams (Johnstone, Al-Naeme, 1991; Heimann, 1994; Mincenkov, 2000; Johnstone, Ambusaidi, 2000; Taber, 2002).

Psychologist J. Korobov (2003), when analysing the reasons of information incomprehension points out the language barrier. The scientist stresses that such a barrier can be created both by the teacher's style of speech, vocabulary and construction of the sentence, as well as by scientific terminology and notions comprised in the material to be mastered. For example, rapid speech when explaining the learning material creates a very fast and impetuous flow of information, which can be understood and remembered only in case the pupils are able to process it similarly fast. Unfortunately, as the author mentions, such a coincidence is rare. If the pupil still manages to "grasp" the material told by the teacher, there most probably will not be enough time for its comprehension, remembering and understanding. Fast tempo of speech not only causes incomprehension but also accustom pupils to think superficial and creates a feeling of discomfort, because "one must try to catch what the teacher says'.

In its turn, the language of chemistry is among the most specific scientific languages. It often seems impersonal to the student because it uses symbols to perform the descriptive function (Kochalova, 2001). Besides, the symbols used comprise a very extensive flow of information. In an ordinary lecture a student has to perceive simultaneously 10-13 units, namely symbols, formulas, equations, mathematical computations, words, whose ordinary meaning may be different. This, of course, makes a large number because only 2-3 specific words are to be found in other subjects. Another particular feature is that chemistry already on the lowest levels of its mastering is focused on abstract processes, which are interpreted by the help of specific symbols, terms and mathematical computations. Its comprehension causes difficulties to many (Cassels, Johnstone, 1983; Johnstone, Letton, 1991). As a result they use mechanically "crammed" and not understood language, whose memorising overloads their operative memory (Johnstone, 1999). A similar situation is in laboratory works when pupils or students must simultaneously learn the work description, equipment, to advance a hypothesis, carry out an experiment, watch the course of process and make conclusions. As a result of these numerous activities there is no time left for cognitive processes. Thus the laboratory work does not fulfil its didactic functions (Cassels, Johnstone, 1983; Johnstone, 2000b; Heimann, 1994; Christen, 1998; Domin, 1999).

It is possible to raise the quality of knowledge acquiring if links are created between themes that have been mastered recently and those mastered previously and the surrounding world (Christen, 1998). It is important to use a repeated explanation that would differ both in terms of depth and its breadth and would correspond to the each level of students (Mincenkov, 2000).

From the psychology point of view the system of images functions better when processing concrete and spatial information, but verbal system - when processing abstract and consecutive information (Paivio, 1990; Sweller, 1994; Vorobjov, 1996; Mayer, Moreno, 1998). Therefore, in chemistry it would be rational to represent an abstract material verbally, for example, transformation of substances on molecular level, alongside with the portrayal of virtual images. It would help young people to create a subject-based connection with the information to be mastered. Thus it would reduce the overloading of memory and it would be easier to reproduce (Russell, Kozma, Jones, Wykoff, Marx, Davis, 1997; Sanger, 2000).

At present already in the first years of mastering chemistry pupils have to learn the structure of atoms, molecules and substances, to write the reaction equations and apply the notion of mole. So they have to learn on all three complexity levels of this science (Johnstone, 1991; Gabel, 1993, 1999; Harrison, Treagust, 1996, 2000; Treagust, Chittleborough, Mamiala, 2003). This, of course, creates an operation memory overload in many of them. To reduce it A Johnstone (1982, 1991) offers a „Multi-level learning" model. The author shapes it as a triangle, the corners of which represent **macro-, representative** – symbolic and **sub-microscopic** levels**.** During the exposition of the learning material the "chemical thinking' of pupils can be shown as a moving along a series of dots located inside the triangle. In order not to overload the pupils' operative memory, these three components should be proportional.

The problem solving productivity to a great extent is determined both by the individual's preliminary knowledge and the capacity of his/her able-bodied memory, as well as the level of cognitive development. In chemistry the solution of problem tasks create serious problems to many pupils and students. As pointed out by the scientists G. M. Bodner and D. S. Domin (2000) they face a problem already at the moment when they distinct between" where I am?" and "where I want to be?"

One of the solutions is to use a differentiated and systematic approach (Volkova, 2002; Bodner, Domin, 2000; Bodner, 2003). The principle of differentiation is essential in the development of mental and cognitive processes, as like in any development also in this case it moves from the general to the concrete, from the whole to its parts, from the indefinite to the definite (Chuprikova, 1995; 1997). This can be implemented making use of tasks of different difficulty level, gradually and by the help of algorithms guiding pupils and students into this process. Development of such tasks can be significantly facilitated using the A. Johnstone (2001) problem type classification scheme.

Thus the growth of student's mental and cognitive self-activity can be promoted if the mastering of themes included in the chemistry programme would be grounded on the observation of proportionality of differentiation and complexity not only when teaching, but also when organizing the process of learning subject mastering.

Guidelines for the improvement of students' learning oriented study process

One of the first steps in the improvement of education quality aimed at the harmonization of higher education in Europe on university level is connected with the identification of fields to be improved and perfected. Thus, in the autumn of 2002 the LMA quality expert group carried out an anonymous poll of the students and graduates with the objective to learn their opinion what and how should be improved in the LMA activity in the future. 242 full-time and 115 part-time students, who had studied at the Academy more than one semester, as well as 34 graduates, participated in the inquiry

The questionnaire consisted of 15 sets of questions arranged both as open-type and partly closed-type questions, which covered different LMA activity aspects. Namely, a) content, organizational and informative – material provision of study programme, b) practice and students everyday life, c) respondents' intensions to continue studies on the following (higher) education level, d) their proposals "What?" and "How?" to improve and perfect in the LMA activity. The sets of questions included in the questionnaire as to their content were similar both for respondents studying at present and for the graduates, but with slightly different wording of questions. It was done intentionally to obtain as comprehensive information as possible on the questions of interest. Thus, for instance, to gain information about the respondents' satisfaction with the content covered by the study programme in the chosen speciality, graduates were asked about that knowledge and skills, which they in their practical work regard as insufficiently mastered or which they do not apply. In its turn, students were offered to evaluate on a five-point scale the subjects that are included in the study programme.

As a result the inquiry provided very extensive information, which the higher education policy makers further used for the determination of guidelines for the improvement of LMA activity aimed at students' oriented studies. Here we will discuss only those inquiry results that determined the guidelines for study process improvement in relation to the improvement of student's own learning capacity.

We know that the development of person's capacities is related to the correlation of his intellect, emotions and will, which actually form also the fundamental basis of independent learning. Besides, learning can turn into an individually essential activity for a person, through joining the emotional and rational fields (Lieģiniece, 2001). Therefore, positive reasons for self-regulated and rational activities of an individual in the learning environment (Holckamp, 1995) is rooted in their motivation and elements of will (Zimmermann, 1989; Schunk, Zimmermann, 1998), which to a large extent are influenced by the student's satisfaction with the study programme's content and learning work organization. In this aspect the inquiry organized by the LMA revealed several existing problems.

Thus, for example, the assessment of the methods applied in the LMA teaching work organization from the point of view of respondent's personal benefit is as follows:

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- (45%) respondents recognize the group work as a teaching organization method, which gives them the biggest benefit; 36% believe that from lectures; in its turn 10% - from workshops and 9% of them believe that they gain this benefit from independent work.

Hence it follows that for most respondents those teaching work organization methods, which require students' own active participation and learning independence, are not important. The reason is evident from the improvement proposals offered by students. Thus, for instance, independent work, which in the LMA is mainly connected with making a definite aggregate of homework in a definite subject for most students is unimportant because (35% cases) respondents (mostly full-time students) in their proposals point out that volume of homework should be reduced. They do not feel their positive effect on learning performance, thus they do not see a particular sense to make them, rather an unnecessary consumption of time. Thus homework in its traditional sense as the one of self-managed learning approaches nowadays does not provide the expected results, thus it is necessary to search for alternative solutions.

Generally respondents' proposals regarding the improvement of teaching work organization were aimed mainly at the improvement of the lecturers' work, and not at the improvement of teamwork of students and university lecturers. Thus it can be concluded that the learning process in the students' vision is a process managed and organized only and solely by the lecturer without their direct participation. This position of students, of course, can be explained by the learning organization system practiced in our country where 'teaching" of the information to be learned is dominating in the literal sense of this word. As a result the aforementioned acts as the totality of factors impeding the individual's motivation to be active and to learn and improve his/her learning ability.

The results of the inquiry analyses disclosed the existence of another aspect of the problem. Thus, for example, in the open-type question: "What are you dissatisfied with in the LMA?" 56% respondents (mainly senior course full-time students) pointed out that in the study process too much attention is paid to general education subjects, such as higher mathematics, physics and chemistry. They also note that these subjects contain too many themes (26% of them particularly mention chemistry) and mastering of knowledge proceeds too fast, thus causing a problem to understand, comprehend and acquire the provided information.

This actually lowers their willingness to master these subjects at all. The worries are strengthened also by the respondents` answers to the question which of the mastered knowledge and skills they do not apply in their practical work. Here the answers include general education subjects: higher mathematics, physics, chemistry, history, aesthetics, and philosophy. Regularities in the respondents' answers show explicitly that not everything is all right with the content of the hard sciences subjects. These shortcomings as well as the "overloaded" study subject content shows, in point of the fact, not only the students' negative motivation to master it, but also identifies a lack of coordination or correlation of the content included in the study subjects (narrower meaning of inter-subject links) with professional subjects. In its turn, according to the cognitive psychology theory (Gage, Berliner, 1999; Baddeley, 1999) and researchers' cognitions (Bodner, 1991; Johnstone, El-Banna, 1986; Johnstone, 1999; Korobov, 2003) the "overloaded" subject content can facilitate overloading of operative memory and hamper further cognitive processes, thus understanding and memorising, linking and recalling of information, its application and stability.

The existing reality determined the need to carry out an additional research, the objective of which was to clarify guidelines for the correction and improvement of the study subject directed at the education harmonization and implementation of self-managed learning concept.

It should be mentioned that in the additional research chemistry had a particular status as a subject the minimum content of which is regulated by the 1978 Education Standard of the International Marine Organization, on one side, and the aggregate of themes traditionally included in the engineering and technical specialities in Latvia, on the other side. Also on the Marine School or secondary education level, alongside with IMO requirements, it includes the mandatory content set out in the secondary education standard. Thus by joining of "emotional" and "rational" spheres the question "What should be taught?" and "How relevant and important it is in today's training of seafaring specialist?" becomes pending.

Guidelines for the development of chemistry teaching content

In the additional research, the objective of which was to identify guidelines for the correction of the chemistry subject's content, there were involved employers (a representative of Seamen's Register and superintendents of some companies) and professors of professional subjects (N=25). The research was carried out in several stages. Initially they identified a link between the chemistry and professional subjects and the significance of this link in these subjects, then they identified the aggregate of the most essential themes which should be integrated into the professional subject study modules to ensure inter-subject coordination (inter-subject link in a narrower sense). It was carried out by the help of a specially developed matrix. The matrix fragment on Table 1 shows that the importance of basic themes and sub-themes to be mastered in chemistry differs significantly.

Table 1. Matrix fragment for the identification of links of organic chemistry and significance.

Organic chemistry themes	Hydrocarbons			Alcohols	Carbonyl compounds (aldehydes; ketones,, carbonic acids)	Carboxyl derivates
	Oil refinery	Fuel and its quality indices	Lubricant and its quality indices	Toxic influence	Solvents, lubricants	Bio diesel fuel
Subjects	Evaluation scale 0 - -5					
Welding	1			1	0	0
	0	0	0	0	0	0
Ship's diesel engines	2			2	2	2
	5	5	5	2	2	5
Ship's machinery	3			0	1	2
	5	5	5	1	3	3
Thermodynamics and heat transfer	1			0	0	0
	0	3	2	0	0	0
Practice in workshops	1			0	0	0
	0	0	1	0	1	0

For example, in the basic subjects for ship's mechanics subjects on oil and its products are topical, in its turn the basic theme on hydrocarbons is of little interest. But from the chemist's point of view hydrocarbons determine the physical-chemical properties of oil products and the sphere of their application.

As a result, to implement the intended the themes to be mastered in chemistry were differentiated by priorities:

- The themes which form the knowledge and skills foundation for full and qualitative mastering of other subjects, but which don't have to be studied profoundly;
- The themes which are crucial for the chosen speciality and should be mastered profoundly.

Thus, to enable the students to better acquire the specific themes, namely to understand, comprehend and remember information included therein and to link it in a unified system with information provided by professional subjects, it was decided to develop a new study subject and integrate it into the

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module course of professional subjects. A proposal was worked out t to unite in one module the newly developed study subject "Quality of energy resources" which includes the most important chemistry themes, with basic subjects of mechanic's speciality "Ships' machines" and "Ships' diesel equipment", and the subject " Thermodynamics and heat transfer". Thus students would be able to perceive and understand fuel and its combustion process from the point of view of both chemistry and physics, as well as from the technical aspect (Kalnina, Priksane, Ivanova, Priednieks, 2005). Like on the university level also on the Marine School (secondary) level a new subject was developed "Basis of branch chemistry". Its integration into the module of professional subjects gave a possibility to connect and interlink the problems of professional aspects (oil and water chemistry) and environmental pollution into the module's content.

The given approach provides students a possibility to acquire systematic information (knowledge) from different fields. Thus the knowledge acquired from different fields and the problem solution experience will not be detached, which according to the psychologists' opinion (which are based on information processing model) would facilitate internal (mental) processes and memory activation and stimulation (Baddeley, 1999; Korobov, 2003), as well as would promote a better comprehension of chemistry (Johnstone, 1999) and motivation to learn (Iljin, 2002).

The next step in the implementation of self-managed learning concept is connected with the development of teaching work organization model for the mastering of chemistry subject content.

Development of independent work organization model

The actual situation in the LMA, which was revealed by the results of inquiry analyses, determined the independent work organization goals:

- The educational goal – to teach students to take over self-learning initiative, through involving in the supervision of his/her own performance or to learn manage oneself.
- The scholar education goal - to teach students to search, to see and explain the existing correlations and regularities determining and influencing technical processes and processes in the nature and surrounding world in connection with the chemistry science.
- The developmental goal - to develop and improve students' research skills, so that on this basis a skill to transform the mastered material and use it in the necessary situation is developed.

The structure for the organization of independent work was developed according to the goals set.

Its implementation was based on the idea of the learning material exposition concept by A. Johnstone „Multi-level learning", namely, observation of the principle of proportionality of gradualness and complexity in the organization of independent work. The given concept determined the work organization structuring elements, namely, the homework, group work and research work was linked in a joint system. And discussions, debates and "cognitive cards" serve as intermediary elements for transition from one level to the next one.

In this system the homework and handouts represent the macro-level, group work – the submicroscopic, and research work – representative level.

Homework tasks and handouts perform the function of the initiators of cognitive processes, as well as facilitate the development of comprehension and view on the theme to be mastered on general level. In its turn, testing of homework, in the form of a short discussion aimed at the consolidation of comprehended information and prevention of possible misunderstandings, is being used as an intermediary element for transition to the next learning level, namely group work.

The aim of the group work is to expand and deepen the acquired preliminary knowledge and to improve the mastered skills, as well as to guide students deeper into research activities. On this level focus is on the alteration of induction and deduction reasoning processes, namely, the students when studying the course of the already known substances or processes are looking for coherence or perceive regularities and try to link it to theory, thus coming to a conclusion that the course of processes in the surrounding world and real life is based on the rules and coherence postulated by "as if abstract" chemistry theory.

Thus a link is being formed between the theory of chemistry and processes going on in the surrounding world and real life (including also in the chosen speciality) with the objective to help the students to get a view about the information being mastered from the theoretical and applied aspect. Thus conditions are created to build a new notion carcass in the memory where theory is already linked to the processes in the surrounding world and real life.

In its turn, during the research work students expand and perfect the acquired knowledge in the previous learning levels and develop (integrative) complex knowledge and skills. It promotes the development of his/her multi-dimensional vision and comprehension of modern chemistry science. Alongside it stimulates the formation and consolidation of self-regulated activity experience. In point of fact, the research work becomes for the student as a "specific self-testing form", revealing the quality of previous learning levels, namely, their skill to link the theory to practice (reality), transforming his/her knowledge and skills into the necessary direction.

Discussion and "cognitive cards" are essential intermediary elements in this learning organization system. Both elements perform the linking function facilitating processing of information and it's recalling in memory. It should be stressed that language and chemistry semiotics in this work organization system represent very significant instruments. Their intensified use activates thinking processes and remembering of acquired information. By organizing the external structure of learning in this way it is intended to stimulate gradual development and perfection of internal structures of chemistry learning.

The efficiency of system's functioning is determined by sets of tasks corresponding to each work organization level. The classification scheme of problem task types by A. Johnstone (2001), comprising eight different types of problem tasks and insight into skills, was taken into consideration in their development. According to it the homework tasks are developed based mainly on first three types, namely, data are given and for their solution students must apply mainly known methods. In group works tasks include the next three types. Sometimes insufficient data are provided for their solution or students must apply unusual data presentation or solution methods. But the research work is already oriented to the investigation of complex issues. Students themselves choose how to carry it out, either as an analytical study of scientific and technical literature, or as an applied, experimental research with a description.

There was an evaluation procedure worked out for the supervision and assessment of students` performance, comprising the assessment by the student himself/herself or by other person. It is based on EFQM distinction model structure elements and synthesised on the RADAR assessment methodology basis (Kalniņa, 2007).

Within the framework of independent work organization system in the process of self-regulated and research activity experience gaining the students were given a possibility to develop and to consolidate integrative knowledge and skills, thus developing and improving the research competency.

Application efficiency of independent work organization system

The theoretically developed independent work organization system in practice was tested initially on the level on LMA structural unit Mechanics Speciality (MS). The experiment consisted of two stages. The first stage lasted from October 2003 till June 2004, and the second from January to June 2007. The participants of the focus group were 30 students of ship's mechanics speciality who in 2003 started studies in the first course of LMA MS and in July 2007 finished studies in this education level.

The experiment participants had finished the primary school in 2003 and they came from different regions of Latvia. They had previously mastered chemistry for two years or on the primary school level.

The experiment started with the identification of preliminary knowledge of the focus group students.

Tests helped to state: the level of students' preliminary knowledge, competency in chemistry semiotics and cognitive field (fact knowledge, understanding of notions and reasoning ability). The test by Liepiņš (1996) developed according to the requirements of the Ministry of Education and Science ISEC was used for testing the chemistry course material of primary school. It included thirty different

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difficulty level tasks with a four answer option. The included tasks were both theoretical and calculation tasks, part of which were with a practical line.

To gain a fuller insight into the scientific comprehension the students were asked to substantiate briefly the choice of answer in the test. The substation was to their mind the most significant, for instance, main basic-: notion, formula, law or a short description of the thought or activity in the Latvian or Russian language.

Determination of the achievement level in the test was based on the point system method (Liepiņš, 2000), establishing that the lowest achievement level gets the student, whose achievement in percent is less than 50%, a middling level gets the student if his achievement percent constitutes 75%, but the higher level must reach 76% - 100% from the total number of points. The breakdown of students' performance in the test are summarised in Table 2:

Table 2. Breakdown of students' performance by levels at the beginning of experiment.

Low level	Middling level	High level
19 students (63%)	11 students (37%)	0 (0%)

It can be seen from the table that principal members of the focus group is constituted by students with low training level in the subject. It is well shown by the data of descriptive statistics. For example, the mean statistical value or the performance of" a "typical student" is 43.9%. There is a broad range between the maximum 70% and the minimum 20% performance. The standard deviation corresponds to 14.9%.

The students' chemistry semiotics, namely, skills of terminology, chemical formulas, application of periodic system are very different and at the same time weakly developed. It was clearly shown by the results of task solution, as well as substantiation of chosen answers. In this field the performance of a "typical student" is 30.43% which is less than students' average performance in test in general. The minimum is 0% and maximum 77.78%, but standard deviation 24.72%. It proves the distinctive differences in the students' performance.

A positive aspect was that each student tried to substantiate the chosen answer. Their substantiations were divided into three groups, namely, they are based on: 1) the individual's intuition; 2) logics of activity and 3) on the science of chemistry. Yet the students' substantiations were mainly based on their intuition. The mean statistical value for this group of substantiation corresponds to 63.05%. In its turn, if we compare how correctly answers were chosen according to the substantiation, then the main statistical value is 15.86%. In its turn, for the group of substantiation that is based on the logics of operation the mean statistical value constitutes 31.14%, and corresponding to the number of correctly chosen answers 23.44%, but for those that were based on the chemistry science it corresponds to 5.33% and number of correct answers 4.43%. The existing differences between substantiations based on the individual's intuition, logics of operation or chemistry science and respectively the number of correct answers is confirmed by the mutual alternative p- value < 0.01 determined by the (Paired Samples T –tests) test method. It proves that with a probability of 99% the mean values of these selections differ significantly. In its turn, if we compare the standard deviation of the difference of all three substantiation pairs then substantiations in the group based on the individual's intuition correspond to 16.76%, on logics of operation already 5.62%, but on chemistry science based substantiations 1.76%. Hence it follows that if the student understands his/her activity and is able to transform the theory mastered in chemistry to a concrete task, and apply in a concrete situation, then the choice of answer is much more precise than in cases when the choice is based only on the individual's intuition. Hence it follows that most of them actually are unable to remember those regularities or interrelations the solution of the concrete task is based on not understanding his/her operation (activity) when solving them.

The analysis of students' performance in the cognitive field (fact knowledge, understanding of notions and reasoning ability) shows that most students have low level of knowledge.

Students' attitude towards the subject of chemistry was identified by the help of an essay. Here it should be noted that students' opinions differs crucially. The biggest parts of students demonstrate a positive approach to the science of chemistry, but towards chemistry as a subject we have noticed some negative shade, and the main reason is in its incomprehension.

In its turn, the inquiry helped to find out students' experience in group and research work in chemistry. Hence it follows that in general in chemistry they have not been provided a possibility to gain either a research or group work experience.

It should be noted that the focus group consisted of 72% students, whose mother tongue was not the Latvian language. The fact that an individual must master chemistry not in his mother tongue, according to researches made by scientists A. Johnstone and Al-Shuaili (2001) may hamper the chemistry mastering efficiency.

Based on the existing reality it was decided to introduce corrections into the theoretically developed independent work organization system, namely, to differentiate the representative level, by introducing a transition stage during which students initially will be into small group projects, and only when they have acquired sufficient experience, in the future teaching process they are directed into scientific or applied research work.

In order to state the perfection dynamics of research competency (RC) during the self-managed learning process three determination levels were developed: elementary; partly independent; independent. They are characterised by four criteria: chemistry learning (knowledge and skills in the subject, set out by the standard of chemistry subject); scientific cognition (research thinking include: cognitive and metacognitive thinking components, problem solving, creatively think), practical activity (include both the use of terminology and proper measurement units, laboratory appliance and vessels, presentation of work results and observance of work instructions); cooperation and communication (include socio – communicative and interaction skills, use "chemistry languages and symbols" are systems for representing and communicating information, experiences, and ideas). Each level has five indices. In case of a positive answer the value of the index is 4 points, but negative – 0 point. The total number of points in one level is 80 points, but maximum number – 240. According to the method for the level determination point system (Liepiņš, 2000), it was determined, if the number of points obtained is then the result is:

- <120 points, then the students' RC is on elementary level, namely, they have mastered the necessary integrative basic knowledge and basic skills;
- 120 – 180 points, then a partly independent competency level has been reached, the student is able to partly independently transform and apply the mastered integrative knowledge and skills in research activity;
- 181 – 240 points, then the independent competency level has been reached, student according to his/her education level is able to transform and apply independently the mastered integrative knowledge and skills in research activity.

The essence of the research activity competency process is rooted in the continuous development of abilities, through the improvement of students' experience and expansion of possibilities to gain the experience, when carrying out practical and research activities both individually and in group, and their results are demonstrated in their ability: to transform and apply the mastered subject knowledge and practical activities, expressing conclusions based on their scientific cognition on processes in the surrounding world.

The dynamics of research activity competency's development and consolidation was measured according to monitoring procedure.

To gain broader and more multiform information on students' learning efficiency and its improvement possibilities, understanding of learning material, motivation and interest in its mastering, the following instruments were used:

- Self-assessment of working group;
- Student's self-assessment;
- Teacher's assessment.

Data of the results of competency development and consolidation dynamics analyses on term 1 and term 2 are summarised in Table 3.

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Table 3. Data of descriptive statistics on the results of the first and second terms.

Criteria	Term	Mean	Median	Mode	Std. Deviation	Minimum	Maximum
Chemistry learning	1	3.,5700	28.5000	25.00	8.76782	19.00	47.00
	2	36.0000	35.0000	28.00	8.67418	22.00	54.00
Scientific cognition	1	27.5333	25.5000	22.00	8.49638	17.00	43.00
	2	32.333	31.0000	33.00	8.53990	20.00	50.00
Practical activity	1	33.5000	31.5000	28.00	8.83469	21.00	50.00
	2	39.0667	38.0000	40.00	8.54575	24.00	55.00
Cooperation and communication	1	27.0667	30.0000	30.00	6.13601	15.00	35.00
	2	42.2333	45.0000	45.00	5.68574	30.00	55.00
PC points	1	119.4000	118.0000	99.00	29.50114	75.00	173.00
	2	150.0000	147.000	120.00	30.21463	106.00	209.00

It can be seen from the table 3 of data analyses that during the first term the focus group research activity competence correspond to elementary level. It can be seen by the mode and arithmetical mean, where Mo= 99.00 < μ = 119.4 and shows that the biggest part of students have gained results located within the lowest point zone, not reaching 50% from the total number of points (120 points), although the arithmetical mean is close to it. Yet in the second term already the biggest part of focus group participants has reached the medium point zone. This is proved by Mo=120.00 < μ=150.00, which proves changes in the research activity competency.

The mean values of criteria were compared by the help of One Way ANOVA (Analysis of variance). For chemistry learning F= 11.101 > $F_{(0.01;13;16)}$ = 3.55; p= 0.000 < 0.01, but scientific cognition F=11.378 > $F_{(0.01;14;15)}$=3.56; p=0.000<0.01, practical activity F=29.055>$F_{(0.01;14;15)}$=3.56; p=0.000<0.01; cooperation and communication F=8.913> $F_{(0.01;5;24)}$=3.90. It follows from the analyses that average achievements by criteria with a probability 99% differ $F>F_{crit}$. This proves changes in the dynamics of research activity competency development.

The students' ability to transform and apply the mastered knowledge, as well as their scientific comprehension from the point of view of chemistry related to the profession and surrounding world were tested at the end of terms one and two by the help of complex tasks.

For the analyses of obtained data there was used the linear regression method. Hence it follows that in both cases the absolute value of correlation coefficient $|r_1|$ = 0.982; $|r_2|$ =0.985; and determination coefficient R^2_1= 0.965; R^2_2= 0.971 points out a close linear connection between achievements in the test work and research work competency. In its turn F- test p_1=0.000<0.001; p_2=0.000<0.001 certify the statistic significance of model. Since actual t_1=27.814> $t_{crit.1}$=4.271 and p=0.000<0.001; t_2=30.440>$t_{crit.2}$=6.067 and p=0.000<0.001, then with 99.9% probability we can assume that there is a linear connection and linear dependence between the achievements in test works and research activity competency.

The performance also of a "typical student" in the test work of term one – 5.77 and of term two 6.30 show that they have reached the neighbouring zone to the middle level.

However, notwithstanding the achieved results in the first stage of experiment, the representative level of independent work organization system was not fully implemented; namely, students because of their insufficient experience were not involved in the applied and scientific research works.

It was realised in the second stage of experiment within the frames of the chemistry subject. Linear regression method was used to determine the competency dynamics of research activity by criteria. The obtained data are summarised in Table 4.

Table 4. Results of regression analyses on the second stage of experiment.

Criteria	Multiple R	R Square	F	Significance F	Constant t	t	P-value
Chemistry learning	0.954	0.910	284.09	0.000	9.298	16.856	0.000
Scientific cognition	0.950	0.902	256.470	0.000	8.888	16.015	0.000
Practical activity	0.936	0.875	196.439	0.000	11.021	14.016	0.000
Cooperation and communication	0.853	0.727	74.567	0.000	10.400	8.635	0.000
RC	0.964	0.928	363.035	0.000	12.022	19.053	0.000

From the Table 4 it is clear that a close linear coherence exists with a 99.9% probability between the criteria of the first stage and the second stage of experiment. In this stage the majority of the focus group participants advanced towards the maximum point zone of partly independent level of the research activity competency, namely, $Mo=172.00 < \mu = 178.6$, which testifies its rapid dynamics.

Students demonstrated their abilities to transform and apply integrative knowledge and skills mastered in chemistry in the theoretical part of the centralised professional qualification examination. The set of exam questions in a computerized way were selected by the officials of the professional education administration of the Ministry of Education and Science of the Republic of Latvia from an aggregate of 1000 questions, thus previously they were unknown either to the students or the lecturers. The set of exam questions was constituted of 80 questions from 12 different subjects, 10 of which were questions representing higher level of difficulty. The maximum number of points for the theoretical part was 100. 14 questions, 2 of which represented the set of higher level of difficulty, were based on integrative knowledge and skills mastered in chemistry. The maximum number of points that a student could get for this set of questions, was 18, bet for others – accordingly 82. The students' performance at the exam was analysed by using the descriptive statistics analysis method. The obtained results are summarised in Table 5.

Table 5. Data of descriptive statistics on exam results.

	Mean	Median	Mode	Standard Deviation	Minimum	Maximum
Exam results	62.80	60.50	54.00	9.618	47.00	95.00
Results on the set of questions not based on chemistry	47.80	4.50	43.00	8.907	37.00	77.00
Results on questions based on chemistry	14.83	15.00	15.00	1.555	10.00	18.00

It can be concluded from the Table 5 that students' performance in questions based on integrated knowledge and skills in chemistry is $Mo=15.00= \mu=15.00$, but on the exam in general $Mo=54.00 < \mu=62.8$. It shows that in the exam in general the most part of the students have gained the result, which is in the medium level 50% point zone, but when answering the set of questions based on integrated knowledge and skills in chemistry a big part of the focus group's participants has reached the highest level, exceeding 76% point zone.

From the One Way ANOVA it follows that with the 95% credibility the students' performance in the exam regarding the set of questions based on integrated chemistry knowledge, has essentially influences the research competency criteria. For example, learning of chemistry $F=3.138>F_{(0.05;6;23)}=2.528$ and

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$p=0.021<0.05$; research cognition $F=3.159>F_{(0.05;6;23)}=2.528$ and $p=0.013<0.05$ have and essential effect as a criteria of practical activity $F=2.075> F_{(0.05;6;23)}=2.528$ and $p= 0.039<0.05$.

The results of statistical analyses testify the efficiency of independent work organization system activity, which gives the students a possibility to develop and improve integrative knowledge and skills and facilitate mastering of manifold experience.

The conclusion is that students that were able to improve their chemistry learning, to explain the conceived based on regularities and obtained results, as well as practical activity, attained high results in test works, namely, in the solution of complex tasks and professional qualification exam.

The experiment on tertiary education establishment's level revealed an analogy with the Marine School level, namely, the existing differences in chemistry comprehension and lack of experience in research activity do not allow realizing fully the representative level of independent work organization system. Since the nature of this process is rooted in continuous development of abilities, through perfection of students' experience and expansion of the possibility to gain this experience, it was proposed to introduce improvements in the study process. Namely, to organize the applied research work as an integrated course work the given approach might promote students' ability to comprehend situations and processes in the surrounding environment in a multidimensional way, to analyse and evaluate reality from different aspects, thus developing and perfecting their research comprehension. And the developed qualitative works would be used for the broadening of teaching material base.

Discussion and Conclusions

According to the changes in the education paradigm in Europe and elsewhere in the world are focused on the student-oriented learning, moving from "teaching" where dominating id the lecturer, to learning by the student himself/herself and his/her involvement in research work. Therefore topical is the issue on the development of learning work organization methods, satisfying modern needs and education quality requirements. Attention of scientists and policy makers is focused on teaching and learning strategies where the individual would acquire a self-regulated activity experience, that would serve as a base for a self-regulated learning aimed at lifelong improvement of education quality.

One learning concept envisages students' self-managed learning, where the nature of the process is to facilitate the development and perfection of person's mental and cognitive self-activity. One of independent learning models is a research-type approach to learning, by which a person learns the content of teaching and is involved in research activity. It has a developing potential because it results from the constant value of research activity. The given model is appropriate for the specifics of the science of chemistry. This learning approach requires stable subject knowledge, comprehension of teaching material and management of learning problem solution. These preconditions are one of the stumbling blocks in the chemistry education. The overload of operative memory is mentioned as a crucial reason, which is caused by disregarding the complexity proportionality when explaining the teaching material (Johnstone, 1999; 2000b).

To stimulate increase of students' mental and cognitive self-activity and reduce a possibility to overload operative memory, the differentiation and complexity proportionality in the chemistry learning process must be observed not only when teaching, but also when organizing the process of mastering learning material. This idea was implemented in a model of multi-level independent work organization system.

This model links homework, group work and research work in a united system. In its turn, debates, discussions and "cognitive cards' serve as interim elements.

Homework and handouts serve as a macro level. Their function is to initiate cognitive processes and promote development of a view and understanding on the given subject on general level. By discussions used for homework checking and analyses by the students among themselves as well as by students together with the professor, transition is made to the next level, namely group work. The given combination of elements:

1. allowed to reduce incomprehension of learning material and to eliminate caused misunderstandings;

2. allowed to consolidate information comprehended on general level;
3. homework analysis and a possibility to use it further in the group work has increased students' motivation and interest to do homework systematically.

Group work in this model serves as a representative level. Its function is to expand and deepen the acquired preliminary knowledge and improve the mastered skills, thus guiding students towards research activity. Here significant interim elements are discussion and "cognitive cards'. The given combination of elements stimulated:

1. intensified use of chemistry semiotics and "specific language";
2. better comprehension and understanding of learning material, and an impetus to perceive regularities between the theory and processes in the surrounding world;
3. inter-connection of mastered learning material and formation of new notions in the memory (the use of "Cognitive cards" for recalling information to memory functions more successfully in case the individual has formed them with understanding).

Research work in this model serves as a sub-microscopic level. Its function is to deepen and improve the knowledge mastered on previous learning levels, thus developing the students' integrative knowledge and skills and forming a multi-dimensional vision and comprehension of the modern science of chemistry. The implementation quality of the above element is determined by the students' (i) research work experience; (ii) confidence in self-regulated activity; (iii) self – control skills. Lack of these skills can be eliminated in case students or pupils in the beginning are involved in small group project work.

The functioning efficiency of the above model is stimulated by:

1. Joining of "emotional" and "rational' spheres in the content of learning subject and offered exercises.
2. Exercises developed in line with students abilities for each model level;
3. Students' involvement in the learning performance supervision, correction of his/her own chemistry learning skills and identification of self-improvement possibility;
4. Observation of emotional and psychological aspects in the work process.

The experiment confirms that the proposed multi-level independent work organization system ensures possibilities to acquire research experience, on the basis of which the chemistry learning productivity, scientific comprehension, formation and perfection of integrative knowledge and skills, consolidation of self-regulated activity experience are facilitated.

The independent work organization system can be applied on any education stage. Its levels can be adjusted according to the person's knowledge, skills and experience. Besides, the self-managed learning experience acquired and accumulated in this way will serve as a basis for lifelong improvement of education level.

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