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Medical Chemistry Course Result Quality Evaluation Criteria and Corresponding Critical Thinking Levels as Evaluation Parameter

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Abstract

Fundamental medical chemistry course allows first year students to verify continuity of knowledge gained in high school as well as to form a continuous learning process from already completed and just started courses. The developed didactic model, organizational work forms and learning materials allow students to adapt to new conditions and intensive work schedule in medical chemistry course. Study materials have been developed over a period of several years and they contain regularities proven by easy to understand examples thus motivating students to distinguish specific chemical processes as well as their causes and effects in given medical problems. Cause and effect analysis in turn develop skills in information analysis that are integral components of competence and critical thinking. Elementary critical thinking skills (how to identify the problem, how to prove arguments as well as to be conscious of contradictions and faults) are effectively developed by medical chemistry course. Critical thinking development methods (different methods of information analysis, problem task solving, graphical information systemization and dialogue skills) are also applicable to medical chemistry course. The experience gained over several years confirms effective mastering of medical chemistry course by using this approach. It is therefore that evaluation criteria for mastering the course material and corresponding critical thinking levels (determinable by final examination) have been developed based on grades of final exams.

Keywords: evaluation criteria, critical thinking

Introduction

Intensive studies, systematic examination and objective evaluation are the main preconditions for quality study process during the semester. Gained qualitative and quantitative data are indications of positive results or aspects which still need development. Evaluation results give information to lecturers regarding the effectiveness of didactic methods and to students regarding their advancement.

Evaluation of knowledge, skills and competence is realized by tests, individual/self-dependent as well as group tasks, problem exercises, laboratory work protocols, demonstrations and final exam. Criteria testing planned in medical chemistry course can be divided into diagnostic, formative, topic oriented and final examination. Evaluation criteria is justified and explained to students thus establishing feedback in order to avoid misunderstandings regarding requirements and adequacy of evaluation. By understanding the criteria used for evaluating student grades and performed work, students gain motivation and justification for adequate self-assessment and improvement.

By assessing own achievements, students - through reflection - critically analyze own strong points thus gaining new stimulation for improvement by purposefully broadening self-realization opportunities and heading towards self-organized study process. Evaluation necessary for development of student's competence and personal progression implies diversity of evaluation methods as well as integration of quantitative and qualitative methods.

Nature of evaluation depends on its purpose. Information necessary for students differs from information necessary for lecturers.

"Evaluation purposes:

1. Evaluation as integral part of study process;
2. Evaluation to gain information regarding success of the program;
3. Evaluation to gain information regarding student achievements;
4. Evaluation to diagnose study process of individual students;
5. Evaluation to strengthen student knowledge before proceeding to the next topic;
   a. Evaluation to show study priorities and develop a certain attitude towards study process;
   b. Evaluation to increase student confidence in their abilities by accenting skills used for accomplishing a task rather than evaluation itself;
6. Evaluation to justify decisions regarding a student;
7. Evaluation to guide towards a certain goal;
8. Evaluation to provide symbolic importance" (Pratt 2000).

Along with already described purposes - consciously or unconsciously - other functions significant to study process may emerge during evaluation: self-evaluation and reflexion on results, linking acquired information with other study subjects, repetition with accent on the fact that given information should already be known within another context.

When planning evaluation, the method of obtaining information, which is to be evaluated, is very significant. In order for evaluation to be successful, following points must be taken into consideration:

- objectiveness and transparency - avoidance of lecturers subjectivity and erroneous verdict;
- individual and differentiated approach - observation of individual qualities of students;
- systemic and compulsoriness - frequent tests for consecutive evaluation and successful planning of study process;
- comprehensiveness - inclusion of all material planned in study program in tests.
- Within medical chemistry course tests, students demonstrate different skills, knowledge and competences and, based on which, tests are categorized by levels accordingly:
- Analytic - highest level;
- Productive - intermediate level;
- Reproductive - lowest level.

Materials and Methods

Medical chemistry course studies are based on didactic principles of university: unification of scientific and training work. Didactic principles determine how to realize regularities in studies in order to achieve certain goals and develop study material and methods for mastering it. Main goals and tasks of the study process are forming comprehension of future medics of human metabolism as set of chemical processes providing vital functions in human organism as well as developing critical information analysis skills in order to discover reasons for pathologies and realize actual solutions for medical problems in a scientifically correct manner. Developed didactic model is intended for providing quality study process of medical chemistry course by using critical thinking development methods.

Medical chemistry course, however, is a base for developing critical thinking which is possible by performing following tasks: learning regularities of critical and logical thinking, comprehension of logical procedures, justification, argumentation of verdict, evaluation and self-evaluation, finding logical errors, since students need to become “critical consumers of information” in chemistry course as well as in other disciplines. For example, when Ennis define critical thinking as "reasonable reflective thinking focused on deciding what to believe or to do," the assumption is that "deciding" usually leads relatively unproblematically to the "doing" (Ennis 1987).

Organization of study process is based on constructional (von Glasersfeld, 1995). and cognitive theories (Bruner, 1996) and is tended towards problem analysis and theoretic or mathematic solutions. Experience gained over several years proves the effectiveness of the developed and probated didactic method within medical chemistry course since results of final exams show stable results. Within the research, two aspects of hypothesis were examined: effectiveness of critical thinking methods in medical chemistry course and comparison of adequacy of usage while working with Latvian and foreign students. Achieved study results can be evaluated using criteria used in medical chemistry course and corresponding critical thinking levels shown by student grades in the final exam.

Exam contains calculation exercises, problem tasks, theoretic questions and their justification with clinical examples or examples of laboratory work done during the semester. Calculation exercises of different complexity allow evaluation of different critical thinking skills. According to obtained results in exam (grades in 10 mark grading scale), students demonstrate gained knowledge, skills and competence in medical chemistry as well as corresponding critical

thinking levels (evaluated indicators of criteria). Indicators of every criterion can be determined based on chosen didactic method and indicators of its effectiveness which emerge in the form of test results (Kazuša, 2012).

"Indicators included in criteria allow measuring and recognizing dynamic of researched phenomenon within existing or artificially created didactic reality by checking execution of tasks. Indicators are specific phenomenon of generalized criteria which allow detecting nature, cause, progression in didactic process, obtained level, etc." (Žogla, 2001).

Table 1. Medical chemistry course material mastering quality criteria and corresponding critical thinking levels as indicators of criteria

Medical chemistry course material mastering quality criteria	Corresponding critical thinking level	Critical thinking level indicators	Tests for evaluation
Analytic - highest level: ● Use of theory for explaining certain phenomenon; ● Understanding properties of linked phenomenon; ● Ability to graphically represent dependencies of physical variables; ● Understanding of experimental justification of theoretic phenomenon; ● Evaluation of experimental results and calculations; ● Understanding of context for researched phenomenon and fact linkage with other disciplines (physics, biology, physiology); ● Ability to navigate through information	High critical thinking level	● Researched situation is evaluated altogether, precisely detected context and conditions of the task without need for additional clarification; ● Logical use of existing information, result prediction, combination of theory and practice, use of given or additional information, reasoning without deviation from topic within solution; ● Verification of obtained result, practical or statistical evaluation, identification of contradictions or errors, analysis and correction, search for alternative solutions and their justification; ● Justification of obtained result only within the scope of	For testing knowledge and skills charesteristic for highest level, reflexion oriented tasks are used, execution of which demands meaningful action, logical judgment and broad generalizations.

sources in order to find necessary information and development of own study method.		existing facts and evidence.	
Productive - intermediate level ● Justification based on theoretic knowledge; ● Knowledge and understanding of chemical regularities and formulations as well as their mathematic justification; ● Knowledge and understanding of chemical designations; ● Understanding of equipment operation and ability to obtain and mathematically process measurements by knowing formulae.	Intermediate critical thinking level	● Verification of obtained result, practical or statistical evaluation, identification of contradictions or errors, analysis and correction	For testing knowledge and skills characteristic for intermediate level, it is necessary not only to test ability to reproduce study material but also comprehend and understand it. Tests cannot be completed based solely on memory since phenomenon must me identified as well as generalized.
Reproductive - lowest level ● Knowledge of separate facts; ● Oral or written description of chemical phenomenon, ability to perform simple calculations; ● Recognition and use of chemical containers and equipment; ● Recognition of certain chemical elements and	Low critical thinking level	Problem recognition. Question formulation for clarifying the problem. Solution process - transparency, logic, analysis of existing information. Verification of obtained result and practical evaluation.	For testing knowledge and skills characteristic for lowest level, reproduction based tasks are used within which students demonstrate their knowledge and skills.

reaction types.			

Within the first semester, most of the students can execute tasks connected with critical thinking only within special study situations. Critical thinking as all-round competence which can be directed towards broad range of problems and situation analysis (high critical thinking level) cannot be observed and evaluated in most of the first year students. Therefore for part of students, only certain aspects of critical thinking used for mastering medical chemistry course are evaluated - certain skills in solving problems, ability to compare one's own solution and solutions of others, effectiveness of information analysis, choice of information credibility criteria and self-assessment which correspond to low critical thinking level.

Research is based on medical chemistry program and consists of:

1. situation identification stage at the beginning of the semester;
2. Evaluation of effectiveness of didactic model at the end of the semester.

Exam results reflect contribution of used critical thinking method to successful mastering of medical chemistry course. The questionnaire results illustrate students' opinion of effectiveness of used didactic model and reflection on their own contribution.

All Latvian as well as foreign students participated in questionnaires at the beginning and end of the semester. Experimental and control groups were not used since parameters determined by questionnaire are directly connected with pass-rate, method effectiveness and cannot be separated from exam results which illustrate progress of all students. Another reason why division in experimental and control groups is not possible is that students participate in medical chemistry course only one year and at the beginning of the semester it is not possible to evaluate group as a single unit. The research was carried out by comparing data obtained at the beginning and at the end of the semester while having students also evaluates the medical chemistry course as a part of their medical education.

The goal of situation identification part is to determine the most effective work forms or distracting factors as ell as student conceptions about studies, medical profession and motivation to learn chemistry. The goal of the second part was to determine effectiveness of didactic model based on identifications of critical thinking criteria, which are characterized by affirmative or negative answers to statements in the questionnaire:

- My new knowledge is always based in previous experience;
- Within new information I always look for regularities;
- New information has to be schematic and visually easy to perceive;
- New information has to be descriptive and broad;
- Chemistry course is basis for medics understanding of vital processes;
- Within chemistry course I learned to analyze and systemize facts as well as predict results;
- Within given study material presentation of facts promotes me to evaluate what is already known and change my opinion;
- Facts given in theoretic material of chemistry course not only logically derive from each other but also show contradictions which must be interpreted according to one's own experience;

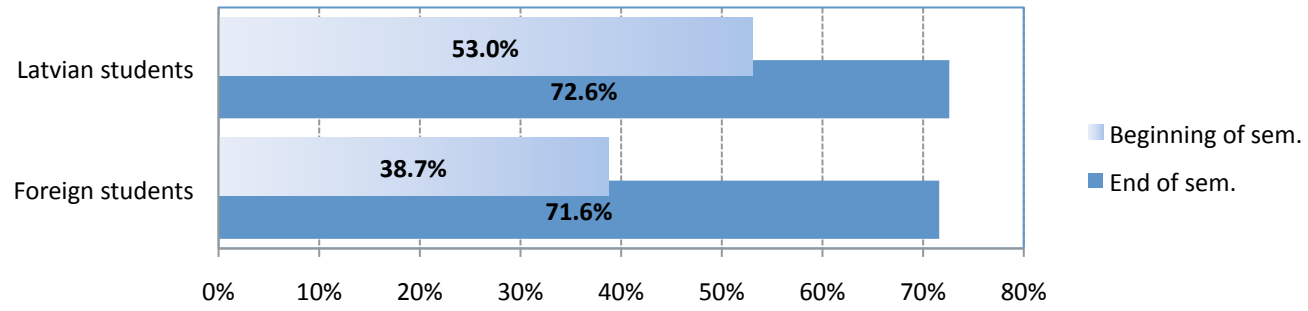
· Theoretic material in laboratory work in chemistry is validated in practical experiments, results of which are statistically processed and justified.

Data from questionnaires illustrates student experience that significantly changes within just one semester. At the beginning of the studies only 53.0% of Latvian students and 38.7% of foreign students base their knowledge in precious experience. Medical chemistry material and practical work promotes students to reevaluate this position and change their approach since by examples in study material they are shown that chemistry is not seperable from other disciplines. Missing knowledge in chemistry can be compensated with knowledge in e.g. biology or physics. At the same time, students realize that insufficient knowledge in mathematics do not allow to fully understand researched subject and its theoretic justification. By understanding concepts of physical-chemical processes, regularities and their nature, students develop general view regarding how it is all connected. This knowledge allows students to explain, model and predict phenomenon and mathematic expressions allow numeric evaluation. Knowledge of processes in e.g. chemical solutions show students link between physical, chemical, biological and physiological processes.

Results of data processing by using Pearson correlation (α = 0,05) (Oxford University press, online resource centers) proves hypothesis of the research - use of critical thinking methods in mastering medical chemistry course is effective.

At the end of the semester 76.2% of Latvian students and 71.9% of foreign students agree with statement: “My new knowledge is always based in previous experience”. Thus it is possible to conclude that didactic method creates or improves study experience for a significant amount of students.

Figure 1 Significance of experience in study process



Statement “Within new information I always look for regularities” describes existing level of critical thinking for 59.5% of Latvian students and 52.6% of foreign students. By looking at this process in dynamic context together with indicators at the beginning of the semester and comparing with results at the end of the semester by using Pearson correlation (α = 0,05) (Oxford University press, online resource centers) the hypothesis of the research is proven - use of critical thinking methods in mastering medical chemistry course is effective since students improve their information analysis skills as well as increase motivation to better

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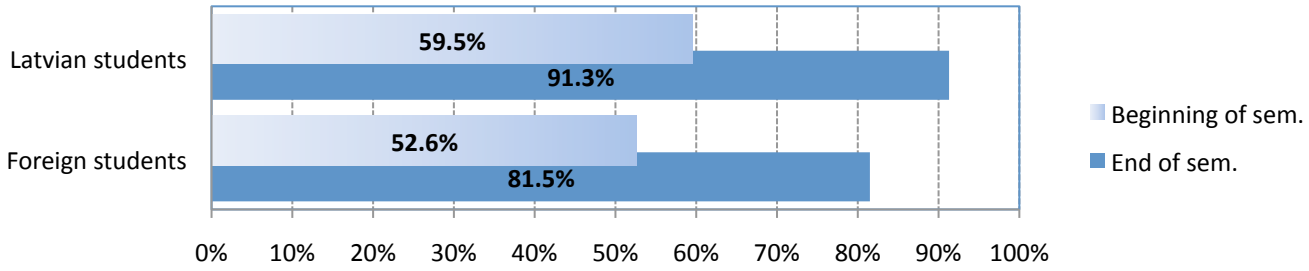
understand the study material. The developed study material promotes critical approach to information analysis and serves as a reference point for using alternative sources of information.

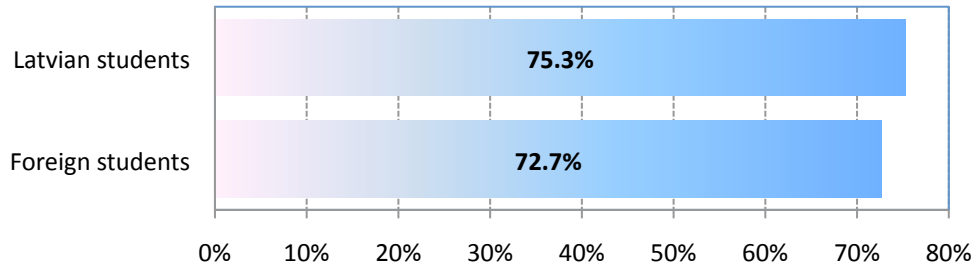
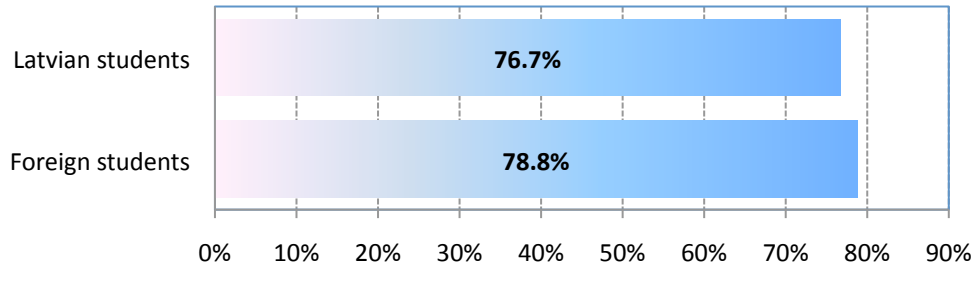
Figure 2 Regularities in new information

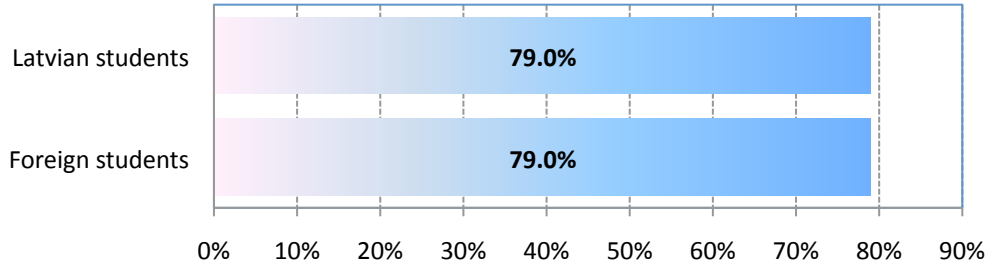
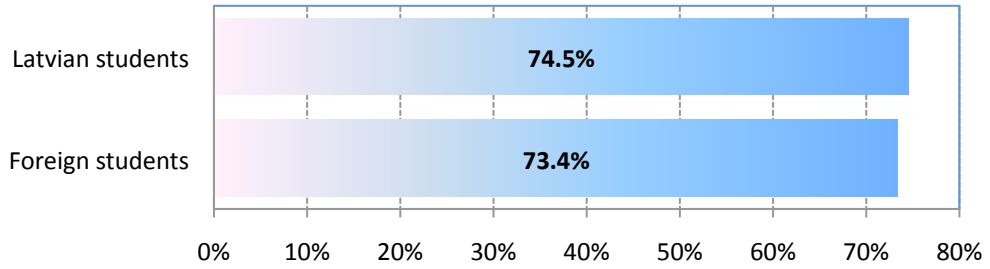
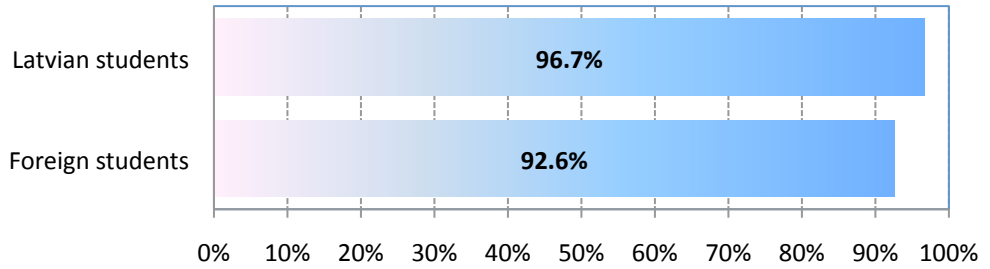


Positive evaluation of didactic model can be illustrated by students agreeing with statements given in table below. By comparing results of Latvian and foreign students using Pearson correlation ($\alpha = 0{,}05$), the difference between both groups is rejected.

Figure 3

Evaluation of didactic model

Nr.	Statement	Results
1.	Chemistry course is basis for medics understanding of vital processes	
2.	Within chemistry course I learned to analyze and systemize facts as well as predict results	

3.	Within given study material presentation of facts promotes me to evaluate what is already known and change my opinion	
4.	Facts given in theoretic material of chemistry course not only logically derive from each other but also show contradictions which must be interpreted according to one's own experience	
5.	Theoretic material in laboratory work in chemistry is validated in practical experiments, results of which are statistically processed and justified	

Comparison between Latvian and foreign students illustrates the current trend in education. Even though high school education level cannot be considered as equal neither in Latvia or in other countries, to students with high level of motivation it does not create problems when studying in university. This relates both to foreign students of RSU and graduates of Latvian high schools.

Conclusions

1. Described didactic model is intended for providing high quality study process in medical chemistry course which is effective and suits students with different previous learning experience.

2. By gaining study experience students become more motivated to learn critical thinking methods. These skills are applicable for analysis of information and structuring of learned knowledge.

3. Regularities of medical chemistry are basis for general natural sciences comprehension, which in accordance to cognitive theory stimulate incorporation of new knowledge into existing ones.

4. Questionnaire process is bidirectional communication between students and faculty, which enable to find out reached effectiveness level of work done, and flexibly react by correcting corresponding methods.

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