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DEVELOPMENT OF CRITICAL THINKING FOR MEDICAL STUDENTS IN CHEMISTRY COURSE

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Abstract

The goal of education is not to obtain qualification and certain skills for whole life any more since nowadays it is often necessary to change orientation of professional activity or to combine several fields of operation. Placing emphasis on high level of responsibility, professionalism and tendency for improvement is expected from medical students. A continuous flow of information puts medical students in front of a choice between already known and new. It is therefore necessary to think flexibly and to be ready to admit mistakes – it is necessary to be able to think critically. The main characteristic of such style of thinking as an intellectual system is ability to analyze all problems, to form systematic bonds, to distinguish contradictions and their solutions as well as to anticipate possible versions of solutions for given problems since intellectual development is not possible without reflection and critical thinking during the process of problem solving. While studying chemistry, students have an opportunity to use critical thinking methods for certain purposes – investigation of laws of nature. Development of critical thinking therefore is an integral component rather than the goal of medical education. Education method is based on the development of critical thinking during practical work, development of study process organization skills, critical analysis of information, situation modelling, self-assessment and self-dependence.

Key words: *critical thinking, study process, didactic methods.*

1. INTRODUCTION

Orientating a teaching process towards active learning, enriching experience in the exchange of ideas is encouraged both by critical thinking and upbringing of individual and responsible action. Students should be aware of themselves as people who can conceive new information and ideas as well as find their practical application. Today's life's speed puts forward a demand for a person to be competent with profound, professional knowledge and variety of skills. As the amount of information in all spheres of life increases, the necessity for self-education becomes very urgent for every specialist during all his life.

Simply being involved in the process of critical thinking is not enough; it must be done well and should guide the establishment of our beliefs and impact our behaviour or action. Critical thinking is an important aspect of modern education as well as a necessary element for gaining success in information era. Though old standards based on good results of standardized tests are still suitable, they can no longer be the foundation of judging academic success or failure (Huitt, 2006).

2. THEORETICAL ARGUMENTS OF THE METHOD

The goal of general chemistry and biochemistry – teach students to use their knowledge about chemical structure of organism and molecular processes in order to understand explanations they are given, information presented on other courses and to prognosticate processes. This approach solves the problem of outdated information: knowledge of main laws and methods used in chemistry and biochemistry helps students (future doctors) to understand, critically evaluate and use new information in order to solve problems.

First-year students of Rīga Stradiņš University become acquainted with basics of critical thinking during philosophy course. Chemistry and biochemistry courses give an opportunity to practically develop critical thinking skills by analyzing and systematizing information describing chemical processes. Critical thinking therefore transforms from separate study subject into didactic foundation which makes study process of theoretical subjects a much more efficient process.

At the beginning of their studies students are not often sure if they can organize themselves in new circumstances and some of them even can't. A negative attitude to the course which demands hard work is sometimes observed because the students are not sure of their abilities. That is why it is necessary to improve students' individual work skills and their learning experience by paying special attention to the importance of young people's critical and creative thinking. Only personal awareness of the necessity of knowledge is the basis for further education during all his life. Study process is the process of getting information, the way it is processed and the final result of which depends on personal contribution, primary knowledge and motivation.

Only few students beginning their studies in university understand the meaning of critical thinking and analytical evaluation of study subjects. Most rarely use critical thinking as a tool for gaining new knowledge. To stimulate overloaded students to master chemistry at a high level is a difficult task that can only be accomplished by interaction of both sides: a lecturer and a student. Without complex critical approach for evaluating new and contradictory information the problem of low level of knowledge will not be solved. In order for students to gain knowledge during studies it is necessary to predict not only course contents but learning process in action as well. In order for students to think critically they must understand intellectual values expressed as continuous development, discipline and knowledge (Paul, 2001; Elder, 2001).

The most effective didactic methods for development of critical thinking, as the research shows, are:

- Special assignments where students have to verify given facts and determine their precision, errors or discrepancy;
- Situations where students are directed towards intensified analysis of conditions of assignment;
- Lecture materials with incorporated logic based examples which emphasize the unproductiveness of unambiguous assessments;
- Mastering of science based research principles which include promotion of theories, repeated practical testing and statistic processing, result analysis and conclusion drawing.

The ability to think critically is vitally important. Of course we do not do our critical thinking in a vacuum. When we are confronted with a claim, usually we already have a certain amount of information relevant to the issue which allows us to find more information if necessary. It can be obtained by developing reading and listening skills and ability to evaluate arguments and predict consequences of statements. (Moore, 1992).

Dewey defines critical thinking as an 'active process' in contrast to a 'passive process', which is the kind of thinking in which you just receive ideas and information from someone else (Dewey, 1910).

The definition of critical thinking has changed somewhat over the past decade. Originally the dominions of cognitive psychologists and philosophers, behaviourally-oriented psychologists and content specialists have recently joined the discussion. The following are some examples of attempts to define critical thinking: (Huitt, 2006).

- ...the ability to analyze facts, generate and organize ideas, defend opinions, make analytical thinking for the purpose of evaluating what is read;
- ...a conscious and deliberate process which is used to interpret or evaluate information and experiences with a set of reflective attitudes and abilities that guide thoughtful beliefs and actions;
- ...active, systematic process of understanding and evaluating arguments. An argument provides an assertion about the properties of some object or the relationship between two or more objects and evidence to support or refute the assertion. Critical thinkers acknowledge that there is no single correct way to understand and evaluate arguments and that all attempts are not necessarily successful;
- ...the intellectually disciplined process of actively and skilfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action;
- Reasonable reflective thinking focused on deciding what to believe or do.

D. Halpern bases her explanation of critical thinking on connection between knowledge and thinking by using which it is possible to create new knowledge form existing knowledge. Goal of her book was formation and development of skills which characterize clear, precise and targeted thinking (Halpern, 2000).

Each of the separate groups has made significant contributions to our understanding of critical thinking. Contributors from the area of cognitive psychology (such as Paul Chance and Richard Mayer) delineate the set of operations and procedures involved in critical thinking. They work to establish the differences between critical thinking and other important aspects of thinking such as creative thinking. Contributors from the area of philosophy (such as Richard Paul) remind us that critical thinking is a process of thinking to a standard. Simply being involved in the process of critical thinking is not enough; it must be done well and should guide the establishment of our beliefs and impact our behaviour or action. Contributors from the area of behavioural psychology help to establish the operational definitions associated with critical thinking. They work to define the subtasks associated with final outcomes and the methodologies teachers can use to shape initial behaviours towards the final outcomes. They also demonstrate how educators can establish the proper contingencies to change behaviour (Huitt, 2006).

In the world of pedagogy there are two basic interpretations - one which explains critical thinking as analytic thinking and which stresses its cognitive aspects (as logical justification and argumentation skills which are necessary for careful reading, analytic reasoning and clear expression of one's thoughts). Thinking skills are an instrument which can be systematically developed.

The second interpretation which begins to appear in theoretical sources from 1998 – 2000 broadens the interpretation of critical thinking. Apart from rational aspect it also mentions emotional aspect as a significant part of critical thinking. Critical thinking is understood as a specific analytically evaluative

way of thinking which is tended on realizing the nature of particular subject and which is characterized by autonomy, reflection, contextualism and interest. Critical thinking includes cognitive, social and communication skills as well as rational and emotional aspects. It is important in point of view of human education paradigm to incorporate both aspects in critical thinking concept. By highlighting only the rational aspect, development of thinkers which are not interested in using thinking skills to benefit society is promoted. Position of such person is authoritarian and cannot be thought of as a critically thinking person (Rubene, 2008).

The question regarding whether critical thinking is as a specific quality which is related to specific scientific discipline or is it a universal thinking quality which can be applied in different situations is very significant.

J. McPeck supports opinion that there is no reason to believe that a person which thinks critically within one field will think critically within others. This opinion is very significant in history of critical thinking development and it has cleared critical thinking concept. However there are counterarguments (McPeck, 1990). Another approach is created by theory of R. Paul, broadening explanation of critical thinking – a universal development of principles of reasoning which can be applied to different fields (Paul, (1990). In an effort to clarify the process of critical thinking, wrote that critical thinking is a unique and purposeful form of thinking that is practiced systematically and purposefully. The thinker imposes standards and criteria on the thinking process and uses them to construct thinking (Paul, 1995).

3. METHODS FOR CRITICAL THINKING DEVELOPMENT

Main differences in literature describing critical thinking are examples which apply to all real life spheres and stress practical use of critical thinking. Specific elements oriented on real life application were chosen and approbated based on experience. As a result a complex method with linked didactic methods was developed. It was used during first-year student practical works in chemistry. Method is based on development of reflexively evaluated study experience which promotes self-determination in study process and future professional career.

By analyzing different methods for developing critical thinking (both universal and specific) active forms of work (practical work, seminars, dialogs, and presentations) were emphasised.

During work with first-year students, deviations from traditional university methods are necessary since there is a transition period. Different levels of qualification and the need to adjust accordingly increases significance of subjective conditions. It is impossible to demand instant analysis – one of the most significant components of critical thinking – of new information from all students.

In order for will to study to transform into targeted and systematic work it is necessary to transform studying based on exam results into development of personal competence. During discussions with students a lack of future goals is evident thus preventing from realizing that studying is a way of reaching goals. The goal to matriculate is reached but there are no new goals.

For this specific reason a material oriented on self-dependant learning „General chemistry" was developed. It approbated interactive methods for practical works as well as factors promoting self-organization skills and development of critical thinking.

Students are unable to evaluate whether one method derives from another, is it an advancement of already known, is it an illustration or contradiction. During reading facts which derive one from another are not spotted. Technical terms are not connected with real life analogies. In order to solve

this contradiction it is useful to create special texts for studying by adjusting them in order to conform to three phase practical work model: suggestion, perception and reflection.

During excitation phase (individual goal determining phase) students actualize existing knowledge regarding study subject, recognize missing knowledge and set individual goals in order to solve the problem.

During comprehensive phase (individual goal realization phase) students evaluate new material, develop personal conceptions and evaluate evidence and arguments necessary in order to discuss the problem.

During reflection phase (personal attitude development phase) students fully understand the problem and are able to analyze their thinking process and problem causes, prognosticate results and draw conclusions as well as to analyze personal mistakes and effort.

Reading, for example, is a macro skill which coordinates several micro skills. Title is the first thing to consider, then comes introduction, then problems or goals of the book. Unclear sentences and interpretations of concepts are considered afterwards. At the same time it is possible to find examples based on personal experience thus validating opinions of the author. These separate steps are joined together in order to create understanding of information read (Paul, 2001; Elder, 2001).

Perception of reading and writing as instruments for development of critical thinking in university is judged very contradictory. E. Volokov criticizes this method and objects against the use of high school methods in university (Volkov, 2009).

Opinion of pedagogues and psychologists which values reflection of writing as an important condition for developing critical thinking skills, for example, theory of L. Vigotsky about relationship between thoughts and language and inner speech, can be mentioned as a counterargument. Written text gives an opportunity to read it again in case of failing to understand it; however it lacks dialogic bond with reader meaning that process of understanding cannot be corrected by changing direction of dialogue and explaining the unclear (Vigotsky, 1982).

This is the skill necessary for obtaining ideas for further consideration and reasoning. However, not enough attention is paid to it both in school and university.

Best methods for text analysis are SQ3R (Halpern, 2000, Huitt,1997). and SQ4R (Huitt,1997). These methods are based on cognitive psychology and they explain how to receive the largest amount of information from books and extramural courses. SQ4R**:**

1. Survey - Read chapter outlines, chapter headings, recaps, objectives, etc.
2. Question - Formulate questions you believe will be addressed in reading
3. Read - Read material quickly, carefully, actively; try to answer previously formulated questions
4. Reflect - Write in journal, make notes, or simply wonder about material
5. Recite - Explain aloud to yourself or another person what you have read; use study guide; answer questions at end of chapter
6. Review - Go back over what you have learned; use study guide; reread recaps, reviews, or end of chapter summaries

Ability to ask thought-out questions is as important as ability to answer. By mastering and using these skills it is much easier to remember and understand information.

Alison King (Table 1) offers questions for guiding thinking process by receiving answers to which it is possible to perform thorough analysis of information (King,1994).

Table 1. Thought directing questions.

Generic questions	Specific thinking skills induced
What are the strengths and weaknesses of … ?	Analysis/ inferencing
What is the difference between … and … ?	Comparison – contrast
Explain why … (Explain how…).	Analysis
What would happen if … ?	Prediction/ hypothesizing
What is the nature of … ?	Analysis
Why is … happening?	Analysis/inferencing
What is a new example of … ?	Application
How could … be used to … ?	Application
What are the implications of … ?	Analysis/ inferencing
What is … analogous to?	Identification of and creation of analogies and metaphors
What do we already know about … ?	Activation of prior knowledge
How does … affect … ?	Analysis of relationship (cause – effect)
How does … tie in with what we learned before?	Activation of prior knowledge
What does … mean?	Analysis
Why is … important?	Analysis of significance
How are … and … similar?	Comparison – contrast
How does … apply to everyday life?	Application to the real world
What is a counterargument for … ?	Rebuttal to argument
What is the best …, and why?	Evaluation and provision of evidence
What is a solution to the problem of … ?	Synthesis of ideas
Compare … and … with regard to … .	Comparison – contrast
What do you think causes … ? Why?	Analysis of relationship (cause – effect)
Do you agree ir disagree to the statement: … ?	Evaluation and provision of evidence
What evidence is there to support your answer?	
What is another way to look at … ?	Taking other perspectives

The goal of questions is to encourage students to follow their way of understanding the read information by "splitting" it into understandable parts to build a general view. The next step in the analysis of information is creation of a monolith idea where graphic organisers are unreplacable.

The use of graphic organizers helps to visualize already known and to add new information as well as to raise argumentation levels. Although reading is by far the most well studied application, science, social studies, language arts, and math are additional content areas that are represented in the research base on graphic organizers. In these subject areas, graphic organizers have been shown to have benefits that extend beyond their well-established effects on reading Operations such as mapping cause and effect, note taking, comparing and contrasting concepts, organizing problems and solutions, and relating information to main ideas or themes can be broadly beneficial.

A graphic organizer is a visual and graphic display that depicts the relationships between facts, terms, and or ideas within a learning task. Graphic organizers are also sometimes referred to as knowledge maps, concept maps, story maps, cognitive organizers, advance organizers, or concept diagrams (Strangman, Hall, Meyer 2009).

1. A Descriptive or Thematic Map works well for mapping generic information, but particularly well for mapping hierarchical relationships.

2. Organizing a hierarchical set of information, reflecting superordinate or subordinate elements, is made easier by constructing a Network Tree.

3. When information contains cause and effect problems and solutions, a Problem and Solution Map can be useful for organizing.

4. A Sequential Episodic Map is useful for mapping cause and effect.

5. A Comparative and Contrastive Map can help students to compare and contrast two concepts according to their features

Lecturers themselves must understand why the selected graphic organizer is appropriate for particular purpose. Only then it is possible to help students understand adequacy of used graphic organizer for systematization of certain facts, ideas and processes

Thought guiding questions in order to focus thinking process:

1. What is my position regarding the subject and which facts, arguments and processes must be understood?

2. Which layout will help to organize material and to show its meaning?

3. What type of graphic organizer will represent the way of understanding the material?

4. Which problems must be emphasized in order to promote thinking process of students (Clarke, 1990).

Graphic organizers analyzed by John H. Clarke are intended for two main purposes. Organization of information which helps students reach conclusion by inductive thinking (graphics "from bottom to top"). Forming hypotheses, making decisions and solving problems using deductive thinking (graphics "from top to bottom") (Clarke, 1990).

Intensification of student thinking process is done gradually by guiding their cognitions toward contradictions. It can be realized by creating problem situations and problem solving exercises. Creating problem situations is effective only in cases when there is a logical connection with already

known. If contradictions between the new and already known cause amazement then there is will to find out more.

J. Dewey highlights „sense of burden" and psychological experience when coming across a problem. In order to solve the problem, J. Dewey suggests a procedure consisting of five steps:

1. Problem description and analysis: "What is the nature of the problem facing the group?"

2. Generation and elaboration of possible solutions: "What might be done to solve the problem we've described?"

3. Evaluation of possible solutions: "What are the probable benefits and possible negative consequences of each proposed solution?"

4. Consensus decision: "What seems to be the best possible solution we can all support?"

5. Implementation of the solution chosen: "How will we put our decision into effect?"(Dewey 1019).

Given tasks included problems which students often solved incorrectly or about which categorical and unproductive conclusions were drawn (conclusions which involve different incompatible solutions). Problem exercises were developed by incorporating already known information which gained different meaning through different point of view. By solving problem exercises students must learn basic principles: statements, consequences, conclusions, problem investigation, evidence an argument presentation, contradiction and imperfection identification. By thinking critically these are not performed as separate operations but rather as complex. Exercise solutions allow evaluating student level of critical thinking.

Development of critical thinking is a long-term process therefore development of evaluation and self-evaluation is a long term process as well. High level critical thinking shows that skills of integrative thinking which are based on logical justified argumentation, criticism and self-evaluation of a professional (university graduate) are obtained (Ennis, 1998, Norris 1998).

Traditional evaluation system concentrates on evaluation of knowledge and skills rather than evaluation of development. Nowadays an emphasis is placed on the importance of self-evaluation.

American education programme and evaluation researcher D. Pratt claims that humanity is the most important aspect of evaluation quality. Careful and human approach to evaluation corresponds to tasks of human reform of education and ecology of environment for development. (Pratt, 2000).

By analyzing experience one must highlight the importance of admitting mistakes rather than the grades themselves. Mistake analysis is one of several steps necessary for self-evaluation. By evaluating study quality students improve their results. An effective self-evaluation process must include two way communications between students and university lecturers. Evaluation of critical thinking can be related with different levels of critical thinking. First-year students cannot evaluate critical thinking as a universal competence which can be applied to problem solving as well as situation analysis. Separate aspects of critical thinking were evaluated – problem solving skills, evaluation of one's own solution variants and evaluation of solution variants given by others.

In order to determine point of reference, students perform tests regarding chemical processes and general thinking operations in the beginning of every semester.

Evaluation of performed work consists of several intermediary evaluations (problem exercises and information analysis) and self-evaluation (questionnaires). Problem exercises and texts provided for information analysis contain information of several "levels". Depending on drawn conclusions and their justification, a scale for evaluation of critical thinking skills is developed. Intermediary

evaluations provide an opportunity to understand necessary corrections. Students evaluated their reasoning and argumentation skills as well as error and cause analyzing skills. They compared their hypotheses regarding processes and results. Intermediary evaluations showed how successfully students solved given didactic tasks of every lesson and how they dealt with study material in general.

Obtained results showed positive tendencies of studying by realizing didactic methods for development of critical thinking. Only 4% of first-year students did not show increase of critical thinking development. Critical thinking as general competence was shown by 17% of first-year students and 79% showed increased critical thinking level (from low in the beginning of semester to medium in the end).

Results of accomplished work are both stimulation to accomplish even more and a material for pedagogic analysis. It is a problem which can be solved by cooperation of students and lecturers. The objective of lecturers is to provide students with interesting opportunities to develop critical thinking skills. It is necessary for students to find subjects they are interested in and methods for studying as well as flexible studying environment.

Results of survey cannot be considered as representative for all first-year students of RSU. However they give an opportunity to evaluate actual situation in faculty of Medicine.

4. CONCLUSIONS

1. Obtained results showed positive tendencies of studying by realizing didactic methods for development of critical thinking
2. Diagnostics are necessary to improve both lecturers' and students' work efficiency and quality. The obtained facts are used for development and realization of new didactic principles in order to improve student thinking process.
3. Effectiveness of different didactic models and methods depends on their suitability for each particular subject and situation. Conformity to different studying forms and skills can be considered as promoting factor for positive attitude towards study material.
4. Obtained critical thinking skills can be successfully used for solving problems not only within chemistry course but in other fields as well.

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