THE EFFECTS OF USAGE OF SEQUENTIAL TEACHING METHOD ON THE ACADEMIC ACHIEVEMENT AND RETENTION LEVEL OF STUDENTS IN AREA OF BIOLOGICAL SCIENCES OR BIOCHEMISTRY

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Abstract

The aim of the paper is to show the application of teaching methods used in the teaching process in teaching the content area of biological sciences or biochemistry, as well as their empirical confirmation by measuring the achievements of the student. Intentional causes for this paper to be written can be found in the fact that in our teaching practice empirical studies that aim to entrust successful application of contemporary models of learning and teaching are extremely rare, which is especially the case in teaching the area of natural sciences, or, more precisely, biology. Institutions of higher education and training within the European Union offer their own proposals for the modernization of the educational process in our schools, but only as examples and ideas that need to be upgraded to suit the conditions of our teaching practice. Models of learning and instruction for teaching biology that will be proposed in this paper rely on the achievements of teaching practice and compatible teaching subject in the countries of the European Union under the title "Science" and "Primary science".

The purpose of this paper is to determine the effects of usage of sequential teaching method on the academic achievement and retention level of students. Three student groups of biology students in University "Goce Delcev", Faculty of Natural and Technical Sciences, Institute of Biology, - Stip, R. Macedonia were offered a topic on general characteristics of *Proteins: Their Biological Functions and Primary Structure* with different sequences of 3 teaching methods. The teaching methods were Laboratory method (student experiment), slide demonstration and lecture method.

Key words: teaching methods, laboratory method, slide demonstration, lecture method, academic achievement, retention level, biological sciences

Introduction

In terms of traditional teaching dominated by the teacher, verbal methods, students' mechanical memorizing, as well as by methods, students - future teachers of biology must prepare and become practically enabled for something quite different. According to Matijevic, gone are the days when the developmental and educational tasks could be pursued by teachers "craftsmen" reproducing the work models they experienced in their education – it is time for the training teachers who are able to create new and original pedagogical situations (Matijevic, 2007).

To make students understand the complex system of knowledge about nature and understand the full complexity of social relations in which they will find themselves, it is necessary that they are directed towards the ways and means of discovering the scientific truth as early as in the earliest grades of elementary school. In biology classes "forms of learning which largely contribute to the development of students' cognitive ability and engage them during most of the lesson, and raise curiosity and interest in further study of phenomena,

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processes and relationships that surround them must be nurtured and applied continually". The emphasis should be on students becoming independent, preparing them for using various sources of knowledge, for connecting the acquired knowledge from different areas, for practical application of knowledge in solving problems in students' daily lives of students, and for creating (securing) conditions for such diverse and creative participation of students in the teaching process. Modern education insists, therefore, on the active role of students in the teaching process, and the teacher is expected to be qualified "theoretically and empirically, and to choose the most appropriate teaching method from the repertoire of teaching methods" (Vilotijević, 1999).

On the other hand, students - future teachers who will work with the above mentioned students in future are insufficiently trained for the practical application of modern, active teaching methods and innovative models in teaching. Research shows that the education of future teachers significantly places greater emphasis on academic content, while their practical and applicable skills and abilities are neglected. Teaching practice in schools is not an equal and important segment of the overall preparation of students for their future careers, but it is just an annex to their theoretical training. This is a consequence of the mistaken assumption that the knowledge acquired in the academic area is sufficient to successfully perform the teaching profession, i.e. of the opinion that mastering "academic disciplines" in combination with "a talent for teaching" is a sufficient prerequisite for the qualitative performance of the teaching profession.

One of the most prominent strategic objectives of the reform of educational systems in Europe over the last decade, "is the establishment of a comprehensive system of (self) evaluation, monitoring and assessment of practical training - an experiment that, as an integral part of the educational system, would provide quality of educational conditions, educational processes and outcomes in accordance with the standards. According to the same author, the analysis of some of the solutions for practical pedagogical training of students in developed countries and regions indicates that the "practical teaching in higher education is given special attention", while research carried out in our country points to the problem of lack of quality student practice, namely "insufficient acquisition, monitoring and evaluation of practical knowledge and skills in colleges.

Teachers in the pedagogical and didactic theory encounter general guidelines for the innovation of teaching, such as: instruction should not be conceived as memorizing facts and concepts, definitions and phenomena, individual differences among students should be respected, student should be brought into a situation to develop their knowledge, etc. But such demands do not trigger response if not observed and re-shaped into precise and specific methodological guidelines aimed at current programme content. The introduction of innovation will be facilitated by providing complete didactic materials which will help teachers to apply these innovations in practice more easily. The use of modern instructional technology does not mean only modernization of the school with new and modern teaching aids, but providing clear guidelines for implementation of the active forms and methods in the context of current educational contents. The teacher must know how to combine modern methods, forms and methods of teaching, or what the advantages and disadvantages of such models and frameworks are, and in what frames they can be successfully applied in our teaching practice.

In an attempt to avoid generalized didactics and out of the desire to leave using teaching methods, which can easily be transformed into routine practice and bare practicing, the basic idea of the work was to show how to shape innovative models of educational organization in teaching biology, i.e. the kind of effect they have on the success of students, or what dimensions the teacher has to take into account in order to meet the frames of contemporary teaching of biology.

Modern methodological and didactic theory needs experimental verification of the application of teaching methods in teaching organization for setting clear signposts of teaching practice.

The acceptance of innovation and improvement of competencies must be the foundation of the professional development of teachers, particularly in the areas of effective instruction and management in the classroom, for the development of the desired pupils' competencies for a life in the contemporary environment, as well as in the goal of getting to an effective teaching and contemporary forms of learning in practice. Biology teaching must reflect the exciting nature of the subject and its surroundings. Student work in biology lessons should be practical and visual in nature wherever possible. In actual fact, teachers often use only lecture

method (without visual aids or demonstrations) in biology lesson in general. There has been a number of researches on the effectiveness of different teaching methods in biology lessons (Galton and Eggleston 1979; Holstein and Lunetta 1982; Johnson 1991; Odubunmi and Balogun, 1991; Killermann, 1998), and especially methods of laboratory and slide demonstration are considered to be very effective in biology teaching. But, these methods must be used in an appropriate sequence. The Methods used in this study will be explained briefly.

Theoretical frame of the research theoretical foundation of the modern teaching of biology

Analyzing certain theoretical positions we just wanted to find a foundation for shaping the innovative models that will be subject to empirical verification, i.e. to detect which teaching methods applied in teaching biology will increase the success of students studying biology, or which will increase the ability to apply the knowledge students acquired?

Today there are many modern theories of learning, as well as modern theories of teaching. They generally include cognitive styles and strategies, multi-intelligence, critical and creative thinking, role of motivation in learning, cooperative learning, interactive learning, and ambient learning. New circumstances create new learning that is more student-active, self-conscious, creative, and autonomous.

We basically start from the systematic - theoretical didactics that applies the methods and procedures of system theory, especially systematic thinking in order to solve problems in a scientific, technical and ideological field. Due to the fact that the purpose of the system theory is to analyze complex systems and prepare technical measures for their effective action, teaching biology here is regarded as a complex system consisting of a series of complex teaching situations. One of the objectives of this research is to discover the elements of teaching situations, then to detect the relations between them, to investigate the criteria under which they act and to lead them to raising the level of students' success. For system -theoretical didactics it does not matter which method will be applied, but the situation for learning is important and it is important which operations a student must perform (observe, learn, to remember).

Contemporary educational and teaching practice in the application of teaching methods for learning finds its asylum in those theories of learning which are putting the focus on the activities of the student, the importance of the discovery, experience and events happening during the process of learning.

In the course of the research three methods are used in teaching biochemistry - teaching unit - Proteins: Their Biological Functions and primary structure:

- Lecture method,
- Slide demonstrations and
- Laboratory method

Research hypotheses

The basic hypothesis is: Students generally have a positive attitude towards the application of the laboratory method in teaching biochemistry, but they do not neglect the importance of other methods (oral lectures and demonstration with slides) as well that are applied during lessons in Biochemistry.

Auxiliary hypotheses we started from in our study are as follows:

- We assume that the students' opinions about lessons in Biochemistry they attended the previous semester are mostly positive;
- We expect students to positively evaluate their practical competence in planning teaching Biochemistry;
- We assume that students' attitudes in terms of their practical training in teaching Biochemistry (determination of operational goals and tasks, appropriate choice of teaching methods, forms of work, teaching resources, literature) are mostly positive;
- We assume that a certain number of students believe that they are not adequately or sufficiently trained for the implementation of some innovative models (programmed, exemplary, problem teaching and different levels of complexity teaching) in teaching Biochemistry.

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Research methods and instruments

The study used a descriptive-analytical method. The techniques used were questionnaire and scaling. The research instrument is questionnaire, i.e. a five-point Likert-type scale of responses constructed by the author according to the defined research tasks. The instrument used did not pass a complex methodological procedure check of exactness and its psychometric properties. It is designed to enable us to gather empirical data necessary to improve certain areas of practical training of students in the field of Biology, i.e. Biochemistry. Through their answers to the questions students should express their views and opinions of their practical training in the implementation of various segments of teaching Biochemistry. The views are grouped by certain segments important for students' professional practical training. Students answer the questions by circling one of the offered responses on the five-point scale - strongly disagree (1), disagree (2), neither agree nor disagree (3), agree (4) strongly agree (5). Objectivity is provided by the fact that they filled out the questionnaire anonymously. The survey results were statistically analyzed using the software package SPSS statistics - version 17.

Research sample

The study included 15 full-time students in their second year of study at the Faculty of Natural and Technical Sciences, studies major in biology at the University "Goce Delčev" Stip, R. Macedonia. This is the generation enrolled in the academic year 2011/12 with the curriculum reformed in line with the Bologna Declaration. The sample was deliberate, because the collection of relevant data should be done by examining the students who attended the course in Biochemistry.

Based on the fact that the teaching of Biochemistry is organized with the aim of better and more efficient professional training of our students, we considered it important that the students themselves assess their practical skills and express their opinions about their professional competence. The results should serve as a basis for modernizing, improving and correcting certain segments of the students' practical training for the realization of teaching Biochemistry in the sophomore year in college.

Lecture method

Lecturing remains one of the more popular methods to transmit information and ideas by teachers, trainers and speakers. As students and audience participants we are quite familiar with the approach. Lectures can be informative, boring and overwhelming depending on the compelling nature of the message and the presenter's style and clarity of message. The lecture method usually is one-way communication and allows for little or none audience participation. The result is audience misunderstanding, loss of information and poor retention.

The traditional didactic lecture method as "an oral presentation given to a class by the teacher" (p. 31), while stated that the lecture or didactic is the method of teaching outside of manipulative work. Teachers are comfortable with the traditional method because they remain in control of content and time (Havice, 1999).

Evidences from a number of disciplines suggest that oral presentation to a large group of passive students contributes very little to real learning. In physics, standard oral-lecture does not help most students develop conceptual understanding of fundamental processes in electricity and in mechanics. Similarly, student grades in a large general chemistry oral lecture course do not correlate with the lecturing skills and experience of the instructor.

Despite the limitations of traditional oral-lectures, introductory courses in biology are forced to offer high-enrolment introductory science courses. Many professors who teach these courses feel that lecturing is their only option, and can only dream of what they could accomplish in smaller classes. However, there is a small but growing group of science faculty members who have developed ways to engage students in the process of thinking, questioning, and problem solving despite the large class size.

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It is important to remember that the ***single overriding goal*** of a presentation is to provide meaningful content in an entertaining way so that participants focus their attention, understand material and are receptive to implementing new ideas back home. The whole preparation, presentation and content of a lecture must therefore be directed not to the speaker but to the audience needs and wants. I encourage you to try some of the techniques provided so that your lectures may be perceived as more interactive, understood, and remembered.

Slide demonstrations

A slide demonstration is an act that a teacher shows and explains something to a class by a prepared PPT teaching tool in Microsoft office software or classically via overhead. This can be used as any educational materials.

Carefully material-selected slide demonstrations are one of the ways of helping students overcome misconceptions, and there are a variety of resources available (Katz, 1991). Slide demonstrations can be very effective for illustrating concepts in the class, but can result in passive learning without careful attention to engaging students. They can provoke students to think by themselves and are especially helpful if the slide demonstration has a surprise, challenges an assumption, or illustrates an otherwise abstract concept or mechanism. Slide demonstrations that use everyday objects are especially effective and require little preparation on the part of faculty. Students' interest is peaked if they are asked to make predictions and vote on the most probable outcome. There are numerous resources available to help faculty design and conduct slide demonstrations.

Laboratory method (student experiment)

Laboratory work is the hallmark of education in science and technology based fields. Student laboratories are a costly resource yet their educational potential is often not fully realized in practice. It is timely that their design and delivery and the forms of student assessment used be examined critically for their contribution to high quality learning (Winter et al., 2001).

The first area of study is the effectiveness of laboratory activities for promoting learning. Practical work is a central theme of lessons in the natural sciences (Galton and Eggleston, 1979; Holstein and Lunetta, 1982). Laboratory work is seen as an integral part of most science courses and offers students a learning environment that differs in many ways from the "traditional" classroom setting (Fisher et al., 1998).

It is important to consider whether learning is more effective if the students do the student experiments themselves or they watch the teacher demonstrating the student experiments. Furthermore, are either of these approaches more effective than the teacher simply describing the student experiments to the students and telling them the results? (Killermann, 1998).

It is hard to imagine learning about science, without doing laboratory or fieldwork. Student experimentation underlies all scientific knowledge and understanding. They provide students with opportunities to think about, discuss, and solve real problems. No science can be properly taught without student experiments. The student experiment should be the central part of science teaching. It serves many purposes. Student experiments are performed to find relations among concepts or to verify hypothesis. As in other lessons, in science lessons the effectiveness is related to the use of teaching methods. Some methods may use together for offering a topic. But, which method must take precedence to increase student academic achievement and retention level?

The aim of this study was to determine the effects of the usage sequential lecture method such as didactic lecture, slide demonstration and laboratory student experiment on the academic achievement and retention (remembrance) level in teaching of enzymes.
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Academic achievement:
Achievement meant that students have possessed immediately after finishing the lesson.

Retention (remembrance) level:
Achievement meant that students' retain (remembrance) which is determined 40 days after finishing the lesson.

Research problem

How does the usage of sequence of teaching methods in science education effect the academic achievement and retention (remembrance)?

Sub problems of research

1. Are there any differences in academic achievement among the groups examined? (Group I-Group II, Group I-Group III, Group II-Group III).
2. Are there any differences in retention (remembrance) levels among the groups examined? (Group I-Group II, Group I-Group III, Group II-Group III).

Methodology Sample

This study was designed as experimental and carried out with three student groups, each of which included 15 biology was designed in second year of University "Goce Delcev", Faculty of Natural and Technical Sciences, Institute of Biology, - Stip, R. Macedonia.

Data Gathering Tools

The work was attempted to establish empirically whether the usage of sequential teaching methods was important for academic achievement and retention. The efficiency was determined quantitatively by a written test. This test contained 25 questions. This test was used as pre-, and post-test before and after methods' applications, and then retention test after 40 days from completing the study.

Procedure and Data Analysis

At first, a pre-test is administered to three groups that each one had 20 students. According to pre-test's results, differences among groups were analysed statistically by using *one way ANOVA* test (Table I), and there was no significant difference (P>0.05) among them.

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Data Gathering Tools

The work was attempted to establish empirically whether the usage of sequential teaching methods was important for academic achievement and retention. The efficiency was determined quantitatively by a written test. This test contained 20 questions (added in Appendix) were selected from University entrance exams by the authors. This test was used as pre-, and post-test before and after methods' applications, and then retention test after 30 days from completing the study.

Procedure and Data Analysis

At first, a pre-test is administered to three groups that each one had 20 students. According to pre-test's results, differences among groups were analysed statistically by using *one way* ANOVA test (Table I), and there was no significant difference (P>0.05) among them.

Table I. *one way - ANOVA test results of pre-test of groups*

Groups	N	Mean	SD
Group I	5	5.05	1.24
Group II	5	4.65	1.51
Group III	5	3.05	1.31
	Sum of squares	df	Mean square
Between Groups	5.23	3	3.95
Within Groups	65.75	16	2.47
Total	40.13	63	

Then, the general concepts and main knowledge of enzymes were taught using three methods in different sequences. The first group started with experiments in the laboratory, then the relevant theory of enzyme was given lecture method, and then the slides were shown by teacher. The sequence of these three teaching methods used in the first group was changed in the second group. In the second group, lesson was started with lecture methods, then used slide show and the latest experiment was done. The sequence of these teaching methods was also changed and the use of the slide show was initiated, then the experiment was done and the latest lecture method was used in third group.

The sequences of teaching methods for the three groups were as follows:
Group I: Student experiment – lecture method – slide demonstration.
Group II: Lecture method – slide demonstration – student experiment.
Group III: Slide demonstration – student experiment – lecture method.

The student experiment's aim was to provide a simple experiment to prove the proteins, reaction which can be easily managed in class. In this experiment, students proved the peptide bones formed among amino acids in the proteins. In 1st tube they put urea crystals which need to be heated, the way biuret is formed. In the second tube 2ml egg solution is put and in the third tube 2 ml gelatine. In all three tubes, 1ml NaOH and 2-3 drops Cu $(SO)_4$ is put, violet complex compound is formed in all three tubes, which shows positive biuretic reaction, which prives the proteins. In lecture method, a lecture presented orally on the general knowledge of proteins without using any kind of media.

In slide demonstration, lecture was performed by showing slides that was containing the explanation of characteristics, structure and study principles of proteins. Each teaching approach lasted in two hours. Then, the same measure tool (pre-test) was applied to each group as post-test. Thirty days after the lesson, it was repeated to each group as retention test. "Delayed retention tests" are research instruments which are administered two or more weeks after instruction and initial testing to measure retained knowledge (Haynie, 1997). Pupils never were aware of any further testing and these tests were not used for grading purpose to avoid the influence of extrinsic variables. Results were evaluated by using *one way ANOVA* test.

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Results

Table II. *Comparisons among groups in point of post-test.*

Groups	N	Mean	SD
Group I	5	5.90	1.65
Group II	5	3.90	1.82
Group III	5	2.10	1.64
	Sum of squares	df	Mean square
Between Groups	21.25	3	22.25
Within Groups	69.90	24	4.05
Total	74.92	26	

In Table II, according to *one-way ANOVA* test results, difference between Group I and Group II was statistically significant (P<0.05). This result suggested that, students' academic achievement level in Group I was higher than Group II students. This *one-way ANOVA* test results established that the difference among the groups' average was significant (P<0.05). This meant that, students' academic achievement level in Group III was higher than that of Group II.

Table III. *Comparisons among groups in point of view retention level*

Groups	N	Mean	SD
Group I	5	51.32	1.89
Group II	5	3.92	1.72
Group III	5	51.34	1.81
	Sum of squares	df	Mean square
Between Groups	8.25	3	4.26
Within Groups	65.12	6.05	4.24
Total	56.34	4.82	

As seen in Table III, the difference between Group I and Group II was significant (P<0.05). It meant that students' retention (remembrance) level in Group I was higher than Group II.

Discussion and Conclusion

The results of this study showed that academic achievement in lessons began with experiment or slide demonstration was higher than lesson beginning with lecture method. In science teaching, using laboratory student experiment or slide demonstration at the beginning of the lesson attracts attention and motivation of students. But, using oral-only lecture bores students and loses their attention to it.

A laboratory setting is a more conducive learning environment than lecture halls (especially for large classes) as it provides students with real life situations and a chance to exercise their problem-solving skills. At the same time, students have more time and opportunities for hands-on experience, active thinking and knowledge reflection. In addition, a teamwork environment encourages students to practice their

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interpersonal skills as well as to nurture team spirit and leadership. Finally, oral presentations provide an opportunity for students to sharpen their mental response and presentation skills.

According to this study's results, retention (remembrance) level in lesson beginning with experiment and slide demonstration was higher than that of beginning with lecture. Because, people remembrance 10% of what they read, 20% of what they heard, 30% of what they saw and 90% of what they had a hands-on experience. Laboratory work is a hands-on experience.

This study has also showed that student comprehension can be enhanced with lesson started with experiment, because these activities increase students' interest in the topics. It is hoped that this study would be a beginning on different teaching methods in biology in Macedonia. Furthermore, the results of the present study could be adapted to any other teaching cases. In as much as teaching method appears to make a difference in student achievement, which method is most effective varies within and across schools and subject matter areas. There was no "best" teaching method across groups of students or different subject matter. The individual teachers are in the best position to determine the most effective teaching method for their particular group of students and their unique subject matter. This finding may even extend to groups of students within classes and change from one subject to the next. This makes a case for the use of a wide variety of methods in teaching all subjects. Further research is recommended to extend this study by including more schools, more classrooms, different agriscience classes, and different subject matter to determine if these results are generalizable. The length of any future study should be extended to an entire unit of instruction or even to a semester to determine if long-term use of lecture or experiential teaching method indicates an advantage to either method.

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