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The effect of teaching methods on cognitive achievement in biology studying

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Abstract

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. The first group started to course with experiments in the laboratory, then the relevant theory of proteins was given lecture method, and then the slides was shown (Group I). The sequence of these three teaching methods used in the first group was changed in both second and third group as follow:
The lecture methods, slide show and experiment in Group II, and slide show, experiment and lecture method in Group III, respectively. Laboratory method used in the study was focused on the topic of This diversity and abundance reflect the central role of proteins in virtually all aspects of cell structure and function. An extraordinary diversity of cellular activity is possible only because of the versatility inherent in proteins, each of which is specifically tailored to its biological role. The pattern by which each is tailored resides within the genetic information of cells, encoded in a specific sequence of nucleotide bases in DNA proteins activity, a student experiment was designed for this reason, and including to examine its features, effective factors, and relation between the structure and function of the proteins. This experiment was carried out by students. Slide demonstration method included slides about protein structure and function. The slides were shown by teachers. Lecture method was performed by teachers as usual. Effectiveness of different sequential teaching methods was measured quantitatively by an achievement test. Achievement test contained 20 questions, testing the knowledge of facts as well as the ability to transfer the knowledge and problem solving ability. This test was used as pre-test before methods' application, post-test after the methods' application and retention test after 30 days from methods' applied.

Keywords: Slide demonstration, laboratory method, lecture method, teaching methods, biology studying.

1. Introduction

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 programmed content. The introduction of innovation will be facilitated

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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.

The aim of the work 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".

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.

2. Theoretical frame of the research

2.1. 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.**

2.2. 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 Ericson (1960) 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.

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.

2.3. 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 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.

3. Methodological frames of the research

3.1. Research problem

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

3.2. 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).

4. Methodology

4.1. Sample

This study was designed as experimental and carried out with three student groups, each of which included 20 biology students in first year The University “Goce Delcev”, Faculty of Natural and Technical Sciences, Institute of Biology.

4.2. 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.

4.3. 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 analyzed 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	20	15.05	1.62
Group II	20	14.65	1.74
Group III	20	13.05	1.45
	Sum of squares	df	Mean square
Between Groups	9.23	3	3.95
Within Groups	125.75	61	2.47
Total	130.13	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 biure 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.

5. Results

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

Groups	N	Mean	SD
Group I	20	20.90	1.79
Group II	20	18.90	1.90
Group III	20	22.10	1.85
	Sum of squares	df	Mean square
Between Groups	41.25	3	22.25
Within Groups	189.90	62	4.05
Total	254.87	67	

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	20	21.62	1.89
Group II	20	18.98	1.72
Group III	20	21.05	1.92
	Sum of squares	df	Mean square
Between Groups	28.25	3	14.26
Within Groups	195.12	61	4.24
Total	220.34	54	

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.

6. 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 looses 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 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 (Beydogan, 2001).

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