**UNIVERSITY OF KRAGUJEVAC**
**FACULTY OF TECHNICAL SCIENCES ČAČAK**


**PROCEEDEINGS TIO 2016**

**6TH INTERNATIONAL CONFERENCE**

# TECHNICS AND INFORMATICS IN EDUCATION

**ČAČAK, 28-29th May 2016**

*Book title:*
**Proceedings TIO 2016**

*Organizer:*
Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia

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*The Conference is supported by the Ministry of Education, Science and Technological Development of Republic of Serbia.*

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*Publisher:* Faculty of Technical Sciences Čačak, University of Kragujevac

*For Publisher:* Prof. Nebojša Mitrović, Dean of Faculty of Technical Sciences Čačak

*Edition:* 150 copies

*Printed by:* Faculty of Technical Sciences Čačak

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# PREFACE

Sixth conference *Technics and Informatics in Education – TIO 2016* which acquired the status of an International conference for the first time this year, pursues an important objective to promote and support research in education of new generations in technical and technological fields at all levels of education, and contribute to technology development and education improvement.

For this Conference, some 86 papers have been submitted within various fields of technical, IT and technology-supported education at all education levels – primary, secondary, high education and education for adults. After reviewing, 71 papers have been accepted for current edition of Proceedings in the form of plenary lectures and original scientific papers by the authors from countries within the region and beyond.

Authors are responsible for any spelling, grammar and stylistic errors in their work.

Conference papers in the *Proceedings TIO 2016* are organized in the following topics:

- Plenary lectures
- Challenges in technical and IT education – from preschool to university
- Information and Educational Technologies
- Professional development of IT and technical education teachers and European educational perspective
- Engineering Education.

Special activities within the Conference are the following:

- Remote experiments - NeReLa Demo session
- Day of Computing
- Poster Session: Research project on Faculty of Technical Sciences

The Scientific and Organizing Committee wish to thank all the scientific and professional employees from various fields who contributed to the Conference.

We would like to thank Partner Institutions which participated as co-organizers of the Conference.

We express special thanks to the Ministry of Education, Science and Technological Development of the Republic of Serbia for financial contribution to this scientific gathering

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*Dr Ivan Milićević, Assistant Professor*

## CHAIRMEN'S FOREWORD

Faculty of Technical Sciences Čačak, University of Kragujevac, has the honour to organize International Scientific Conference 'Technics and Informatics in Education – TIO 2016'.

The Conference continues the tradition of gathering scientific associates and professionals in technical, technological and IT education in primary and secondary schools in Serbia. For the last 50 years this assembly has been organized in various forms (scientific and professional conferences and consultations on technical education, information technologies, technical seminars, etc.). These scientific and professional conferences have had a huge impact on the development of technical education, mostly in primary education, as well as in secondary education. The impact is also noticeable in both higher and university education. Five National conferences with International participation titled Technics and Informatics in Education were held in 2006, 2008, 2010, 2012 and 2014. Still, the necessity for continuous, organized scientific assembly related to technics and informatics in new surrounding and connection with other technologies has increased.

The aim of the conference TIO 2016 is to improve the exchange of knowledge and experience between experts, scientific associates and professionals from Serbia, neighbouring countries and Europe, engaged in the subject matter. The conference will provide an analytical review of technical (technological) and IT education, as well as education regarding technical (technological) and IT achievements including assistive technology, teaching aids, student books, etc. Teacher training is considered highly significant for research and development in education in this field.

The Conference includes technical (technological) education at all levels: from preschool institutions, primary and secondary schools over higher and university education, to various forms of lifelong learning.

Furthermore, the special emphasis will be given to the place, importance, and role of informatics and IT in technical and professional education, as well as correlation with other natural, social and education science.

A comprehensive analytical review will be given on the state of education in the fields of technics and informatics, as well as the contribution of technical and IT education to other fields.

The conference results are expected to provide the basis for planning the development of education in Serbia, especially in the fields of technical (technological) education, engineering, IT and informatics. The results are also expected to support and contribute to the exchange of educational patterns in the neighbouring region and coordination with European trends in this field.

We hope that experience gained at the Conference will be very useful both for the participants and for the development of technical-technological education field.

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**TECHNICS AND INFORMATICS IN EDUCATION**
**6th International Conference, Faculty of Technical Sciences, Čačak, Serbia, 28–29th May 2016**
**TEHNIKA I INFORMATIKA U OBRAZOVANJU**
**6. međunarodna konferencija, Fakultet tehničkih nauka, Čačak, Srbija, 28–29. maj 2016.**

UDK: 371.388:372.857 Original scientific paper

# The pedagogical benefits and pitfalls of applying tools for teaching and learning laboratory practices in the biological sciences

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***Abstract**: The aim of this study is to research the different methods used by biology teachers and their effects on the success of the students. Three student groups of biology students in University "GoceDelcev", Faculty of Natural and Technical Sciences, Institute of Biology, - Stip, R. Macedonia were offered a topic on general characteristics of Hemoglobin, Methods Based on color development (Sahli's/acid hematin Method) with different sequences of 3 teaching methods. The teaching methods were Laboratory method (student experiment), slide demonstration and lecture method. The first group started the course with experiments in the laboratory, then the lecture method was given to relevant theory of proteins, and then the slides were shown (Group I). The sequence of these three teaching methods used in the first group was changed in both second and third group as follows:*
*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 Estimation of hemoglobin - Methods based on color development (Sahli's/acid hematin Method)*
*This experiment was carried out by students. Slide demonstration method included slides about hemoglobin 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

In respect to traditional teaching dominated by the teacher, verbal methods, mechanical memorization by students, students - future teachers of biology must be prepared and practically trained for something completely different. According to Matijevic, gone are the days when the developmental and educational tasks could have been realized by teachers 'artisans' by just reproducing the models they met with during their education - it is time to

educate teachers who are able to create new and original pedagogic situations (Matijevic, 2007).

To make students perceive the complex system of knowledge about nature and understand all the complexity of social relations in which they will find themselves in future, it is necessary, as early as in the first classes of elementary school, to suggest students the ways and means of gaining scientific truth. In teaching biology "such forms of learning must be nurtured and continuously applied which largely contribute to the development of students' thinking skills, engage them most of the time during class" (Cvjetičanin, 2008), stirs curiosity and interest for further study of phenomena, processes and relationships that surround them. Emphasis should be on making students independent, preparing them for using different sources of knowledge, on linking knowledge acquired in various fields, on practical application of knowledge in solving problems in students' daily lives, and on providing conditions for as diverse and creative participation of students in the teaching process as possible. Modern education insists, therefore, on the active role of students in the teaching process, and teachers are expected to be able "theoretically and empirically, to select those most appropriate from a wide repertoire of teaching methods" (Vilotijević, 1999).

One of the most prominent strategic goals of the reform of educational systems in Europe during the last decade, "is the establishment of a comprehensive system of (self) evaluation, monitoring and evaluation of practical training - an experiment which, as an integral part of the educational system, would secure the quality of educational conditions, educational process and its outcomes in accordance with educational standards. According to the same author, the analyses of some of the solutions for practical pedagogical training of students in developed countries and regions indicate that "practical training during higher education is given special attention", while research conducted in our country points to the problem of the lack of quality student practice, i.e. insufficient acquisition, monitoring and evaluation of practical knowledge and skills at universities.

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.

## 2. THEORETICAL FOUNDATION OF THE MODERN 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.

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).

In the course of the research three methods are used in teaching physiology, teaching unit - Hemoglobin - Methods based on color development - Sahli's/acid hematin Method.

## 3. RESEARCH HYPOTHESES

**The basic hypothesis is**: Students have generally positive attitudes when it comes to the application of laboratory methods in teaching physiology but they do not neglect the significance of other methods (oral lectures and slide demonstrations) applied during classes of physiology.

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

- We assume that students' opinions about physiology classes they attended in the previous semester are mostly positive;
- We expect that students positively assess their practical skills for planning the teaching of physiology.

### 3.1. Research methods and instruments

The research was conducted using a descriptive-analytical method. Interviewing and scaling techniques were used. The survey instrument was a questionnaire, i.e. a five-point Likert-type scale, constructed by the author of this paper according to the defined research tasks. It is designed to enable us to collect empirical data necessary to improve certain areas of practical training of students in the field of biology, i.e. Physiology.

### 3.2. Research sample

The study included 27 students of the second year of studies at the Faculty of Natural and

Technical Sciences, study program in biology, at "Goce Delchev" University " in Stip. This is the generation that enrolled in 2012/13 academic year, after the curriculum had been reformed in accordance with the Bologna Declaration. The sample was intentional because the collection of relevant data was to be done by testing students who attended classes in the teaching subject Biochemistry.

Starting from the fact that the teaching of Physiology is organized with the aim of better and more efficient professional training of our students, we considered it important that students themselves assess their practical skills and express their opinions about their professional competence. The results obtained should serve as a foundation for modernizing, improving and correcting individual segments of students' practical training for the realization of teaching the subject Physiology at the second year in college.

The first part of the questionnaire includes personal information about the teachers. The second part included questions on teaching methods, the aim of biology teaching, factors affecting the teachers' choice of methods and an open ended question about what method or methods should be used to increase the success level of the students. In the third part, some views related to teaching methods have been put forward, and the teachers were asked whether they agreed with these views and these views were evaluated using the Triple Likert Type measurement tool. The frequency, average and ratio distributions of the data obtained by the questionnaire were calculated by using the SPSS-15 packet programme.

### 3.3. 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).

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.

### 3.4. 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.

### 3.5. 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.

## 4. METHODOLOGICAL FRAMES OF THE RESEARCH

### 4.1. Research problem

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

### 4.2. 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).

### 4.3. Methodology, Sample

This study was designed as experimental and carried out with three student groups, each of which included 27 biology students in first year The University "Goce Delčev", Faculty of Natural and Technical Sciences, Institute of Biology.

### 4.4. 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.

### 4.5. Procedure and Data Analysis

At first, a pre-test is administered to three groups that each one had 27 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.

Then, the general concepts and main knowledge of Hemoglobin 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.

Methods based on color development of hemoglobin

The commonly used methods are Sahli's/ acid hematin method and Cyanmethemoglobin method. The details of these methods are described below.

Sahli's/acid hematin Method

Principle: Blood is mixed with N/10 HCl resulting in the conversion of Hb to acid hematin which is brown in color. The solution is diluted till it's color matches with the brown colored glass of the comparator box. The concentration of Hb is read directly.

Equipment required

Hemocytometer which consists of

- comparator box which has brown colored glass on either side
- Hb pipette which is marked up to 20mm3(0.02ml blood)
- Tube with markings of Hb on one side
- glass rod
- dropper

**Reagents required:**N/10 HCl and distilled water

**Sample:** Venous blood collected in EDTA as described earlier

**Figure 1.** *Hb comparator box with brown glass on either side and tube with acid hematin solution in centre. The color of the solution is matched with the glass and the concentration of Hb is read directly*

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 1.** *Comparisons among groups in point of post test.*

| **Groups** | **N** | **Mean** | **SD** |
|---|---|---|---|
| Group I | 27 | 21.42 | 1.82 |
| Group II | 27 | 18.90 | 1.90 |
| Group III | 27 | 21.93 | 1.76 |
| | Sum of squares | df | Mean square |
| Between Groups | 39.95 | 4 | 21.75 |
| Within Groups | 193.43 | 64 | 3.87 |
| Total | 254.87 | 69 | |

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 2.** *Comparisons among groups in point of view retention level*

| **Groups** | **N** | **Mean** | **SD** |
|---|---|---|---|
| Group I | 27 | 22.16 | 1.79 |
| Group II | 27 | 19.34 | 1.83 |
| Group III | 27 | 22.34 | 1.85 |
| | Sum of squares | df | Mean square |
| Between Groups | 31.485 | 4 | 13.89 |
| Within Groups | 189.32 | 61 | 3.86 |
| Total | 2230.41 | 57 | |

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 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 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).

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. The same results should not be expected from students who are physically, spiritually, logically and socially different from each other because each student will study and reach conclusions according to his/her condition and capacity. In addition, it is clear that in order to increase the success of the student, the use of laboratories, and the question/answer and demonstration methods are all necessary. But the reason why teachers prefer the narration method instead of the laboratory method is the unavailability of biology laboratories in many high schools, insufficient materials and tools and the excessive number of students in classes. However, in teaching biology, observation and experimentation methods are emphasized as being very important. Conscious learning cannot be achieved without giving importance to experiments. Through experiments, students learn learning by doing, using materials and tools correctly, doing-recording and summarizing, and also by evaluating (Gerçek and Soran, 2005).

Another reason is that biology curricula are heavy and lesson hours are inadequate. It has been found that the education a student receives at university is effective in choosing methods. Gerçek and Soran (2005) support our findings. It has also been established that teachers seldom use the visit and observation method as it means greater responsibility for the teacher of the students on the trip and because of financial problems. In fact, biology is a discipline strongly connected with the environment; therefore, the environment makes for a natural learning place for the students to understand the relationships between nature-humans and living things nonliving things.

As a result, biology teachers should focus on teaching methods that help students to understand essential concepts and develop their reasoning skills together with scientific methods

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