University "St. Kliment Ohridski" – Bitola
Faculty of Education – Bitola

TEACHER
International Journal of Education

Vol. 25
Bitola, May, 2023

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Faculty of Education–Bitola
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National and University Library "St. Kliment Ohridski"–Skopje.

TEACHER: Journal of the Faculty of Education–Bitola /
[Editorial Board Acad. Grozdanka Gojkov ...] Year XXI, No. 1 (2023) -.
- Bitola: Faculty of Education, 2023 -. - 29 cm., 113 p.

Unspecified

ISSN 1857- 8888 (online)

University “St. Kliment Ohridski“ – Bitola, North Macedonia
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The journal has no commercial nature.

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"St. Kliment Ohridski" University
Faculty of Education - Bitola

eISSN: 1857-8888
DOI: 10.20544/teacher.25.08

THE IMPACT OF EXPERIMENT-BASED TEACHING ON LEARNING THE SUBJECT CHEMISTRY IN LOW SECONDARY EDUCATION

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Abstract

Experiment-based teaching is a learning strategy by which students gain knowledge and skills through investigating, answering questions, collaborating, self-managing, and solving problems through communication, while the traditional method serves ready-made information to students that vanish very quickly. Therefore, in this paper, the topic of experiment-based teaching in chemistry and the role of incorporating experiments in students' learning and development of their skills and abilities have been closely examined. This research implies an action research methodology, with a quasi-experimental design, and is conducted in Primary school „Dardania" in Municipality of Pristina, from which students of two seventh grades participated. The pre and post-test method was used in the classroom where the lesson instructions were based on experiments, while in contrast, in another classroom with a group of students who served as a control group, the teaching was realized by applying the traditional teaching methods.

Overall, the techniques and instruments of the research included the following: pre-test, observation of students during the learning process, checklist, and post-test. The research results showed that in the classroom where the learning is based on experiment-based teaching, the students are more motivated and active and show higher results in learning chemistry compared to students who have learned the same units based on traditional methods without integrating experiments. The practical value of this research relies on providing valuable results in encouraging teachers to use experiment-based teaching more often so that students can gain practical knowledge and skills to practice experimental work as the results indicated that students who learn in classes where teaching based on experiments is used, achieve higher results and show higher performance in the subject chemistry than those who have completed the lessons in classes where traditional methods are used without applying experiments.

Key words: chemistry, learning, experiment-based teaching

1. Introduction

Due to enormous and rapid change in educational reforms in Kosovo, without a proper analysis and feasibility studies, a lot of problems have been caused and placed in surface in the educational sector. Reforms in education include legislation, curriculum and infrastructure. Regarding the new reforms, the main achievement of the new curriculum is related to efforts

to putt students in the center of the teaching and learning process. Putting the student in the center does not mean being content with using same teaching techniques, which in the pedagogical literature are known as "student-centered learning techniques", but the teaching mindset must be changed, and the perspective must be changed (Berisha, R, 2011). Experimental learning is a student-centered learning and curricular approach that requires students to apply knowledge and skills to propose workable solutions to problems (Sousa, C, 2014).

The chemistry subject offers a special perspective of understanding the environment in which we live. Learning in the natural sciences is perceived as different from learning in other fields, as it differs in these aspects: in the way it collects data and interprets it; in the way information is validated before general acceptance; and by recognizing the limitations of scientific research and knowledge in the fields it deals with (DEIL, 2007). The Ministry of Education, Science and Technology (MEST) adopted the New Kosovo Curriculum Framework (KCF) in 2011 as an effort to improve the quality of education in Kosovo and to harmonize with developed countries. This framework is supposed to facilitate a shift from objective and content-based methodologies to contemporary teaching and learning methodologies based on student outcomes and the development of student competencies (MASHT, 2016). The development of scientific education is a key element for development of the society in any country of the world. In order to achieve a higher level of scientific education, continuous efforts must be made to improve and acquire new teaching methods, replacing more and more traditional methods every day. Current traditional education is very important to change, both in the teaching of the subjects of natural sciences, such as chemistry, biology, and physics, as well as social sciences, in order to bring positive effects to enhance students' skills and abilities.

According to the different stage of the lesson, the activities can be classified into the following types: introductory activities; activities of the main part of the lesson; (students' activities) and activities in the final part of the lesson (activities for reflection and evaluation); such as activities conducted through an analytical diary; five minute composition, etc. (Pejchinovska, M., Kamchevska, B, 2015).

Natural sciences represent the curricular field, which offers students the opportunity to develop an understanding of concepts, theories and basic laws of the development of nature (MAS, 2014). Therefore, in order to understand and learn natural sciences as well as possible, the teacher must find the most effective teaching method and suitable activities and create the curriculum according to the necessary learning requirements (Holubova, 2008). Teaching with the student at the center requires greater commitment from both students and teachers. The student should be a more active thinker and researcher while the teacher should become a facilitator and mentor instead of being a source of information (MASHT & USAID, 2013). Thus, numerous researches have shown that the teaching of natural sciences based on experiments enables the promotion of student learning and provides more efficient lessons than traditional methods in both social sciences and natural sciences (Kingston, 2018). From this form of teaching, the students connect the previous theoretical knowledge with the new practical knowledge, which will benefit them through experiments and demonstrations in the subject of chemistry.

2. Literature review

Prior empirical studies in the natural sciences have established the importance of conceptual understanding of the topics. The most important objective in natural science research is the construction of a methods and activities that can help students in understanding scientific and

alternative concepts. Example, for effective approach in teaching and learning natural sciences is the program Learning Through Research that is realized in both, the theoretical and practical work of the primary school teachers, who follow these procedures: research process, research characteristics and application, the objectives of the research procedures in class; teachers' and students' tasks in the research procedures in class; a review of the mentor's role in the research procedures; the meaning and the role of the teaching forms in the research process – individual and group approach in the RPs application; observation of the class –components, stages, and types of observation; survey and interview and their application in class; case study; taking up roles; experiment and application of the experiment in class. (Pejchinovska, M., Talevski, D. J., Janusheva, V., 2014).

Natural sciences represent collection of knowledge that includes facts, concepts, principles and theories, and which can be called both science and product (Laksana, 2017). Experimentation-based learning is a compressive (or optimal results) approach to classroom learning that is designed to engage students in complex investigations, authentic problems, and careful responsibilities and assignments (Özdemir, 2006). Various collaborative teaching frameworks have been developed across curriculum, and studies have shown the effectiveness of these collaborations in promoting learning and social connections for students, compared to traditional classroom learning methods (Holst, 2003). Experiment-based teaching is not complementary to the activities that support learning, but it is based on the curriculum and presents an approach in the form of instructions that teaches the concepts of the curriculum through practical laboratory work. Education in natural sciences is an important part of students' general education at school. In the age of information explosion and rapid development of technology, today it is impossible for the school to be conceptualized as the place where knowledge is transmitted to children and then they are asked to reproduce it (Musai, 2015). Habok and Nagy (2016) add that experiment-based teaching is not only a substitute for increased teaching and learning activities, but it is a fundamental part of curriculum that includes a project-based approach to develop skills that are very necessary for situational teaching. In general, teaching based on experiments is a method that includes the combination of theory and practice or rather knowledge and doing. This refers to the process in which students gain knowledge from the core curriculum and from what they know in solving authentic problems, to ensure the best results (Mujtaba & Zuana, 2013).

The application of experiments in the teaching and learning of chemistry is an institutional approach that coordinates curriculum-based learning, linking theory with practical laboratory work, enabling students to face more complex tasks and questions, or problems that involve solving them, making decisions, and investigating skills by the student himself who is supported by the teacher (Kim, 2016). Through experiential teaching, students learn all the concepts of the curriculum. Experiment-based teaching is based on sufficient questions that guide inquiry and allow students to apply their knowledge (Bell, 2010). In teaching and learning the subject of chemistry through experiments, the tasks have special importance, being structured on the basis of questions and problems that are very challenging and require students to draw up a plan on how to solve the problems, how to make a decision about those problems, how to develop investigative skills and provide opportunities for students to learn independently (Parëati, Suarni, Suastra, & Adnyana, 2019). Experiential learning is a method in which students work together to investigate real-life issues and problems, using problem-solving strategies and various resources to produce a final product (MASHT & USAID, 2013). Furthermore, in his study on making chemistry teaching relevant, Holbrook (2005) summarizes the results of several studies on the relevance of chemistry teaching issues. Among the many problems encountered, some include the fact that the teaching of chemistry is unpopular and irrelevant to students, although there is believed to be a failure to promote higher order

cognitive skills. Therefore, gaps are created between what students want to learn and what they already learn. Teachers and teaching chemistry are not changing; this might be the reason teachers fear change and need professional development. Learning in the natural sciences aims to equip students with skills in acquiring and managing information. Learning focuses on integrating habits, from basic to complex processes, leading to creative problem-solving, decision-making, and investigative consideration (Musai, 2015).

Through the teaching carried out with experiments, the teachers will create a positive and motivated cooperation with the students, which will impact their engagement in planning the experiment and innovative future activities. This could serve as a way to improve students' knowledge in the subject of chemistry by involving them in various learning activities and integrating theoretical and practical perspectives, followed by the implementation of practical laboratory work, which was perceived as a challenge so far.

3. Methodological framework

The methodology of this research is action research, by means of any systematic inquiry conducted by teacher-researchers, principals, or other researchers in teaching/learning environments to gather information about how their particular schools operate, how they teach, and how well teach their students (Kingston, 2018).

To carry out this research successfully, we used the quasi-experimental design, including two main elements: an experimental class and a control class. *The experimental class* is also called the treatment group, because it receives the experimental procedure (intervention), in order to test the results. In this way, the group used the experiment as an approach to answer on the research problem. *The control class* is the group in the scientific experiment that is not exposed to any experimental changes.

For teachers of natural sciences, the organization of practical laboratory work is more complex than social work, because it involves understanding natural phenomena and processes or the environment through experiments and demonstrations, etc. Teachers must be well prepared for lessons by planning the programs carefully and considering the students' needs, abilities, and interests for learning, so that the teaching and learning process would be effective. Therefore, the purpose of this research is to identify the impact of experiment-based teaching on the learning of science and chemistry in seventh grade students, understanding the role and importance of experiment-based teaching in improving students' outcomes as well as the impact of this method on the planning and implementation of the lesson.

The research question that guide this study include: *What impact does experiment-based teaching have on seventh-grade students' late learning in chemistry? Does the application of experiments affect the stimulation and motivation of students for the subject of chemistry?*

General hypothesis: H 1: Students who learn in classes where teaching based on experiments is used have achieved higher results and performance in the subject of chemistry compared to students who have completed the lessons through traditional methods.

Special hypotheses H 2: In the classes in which the experiments were applied, students' interest in the subject of chemistry has increased compared to the students who have completed the lesson with traditional methods.

Sample of the research. The research was conducted in the „Dardania" lower secondary school in the Municipality of Pristina, where 44 students of the 7th grade took part in the study's sample.

Class VII - $_1$ (with 22 students) was an experimental class where learning was developed through experiments, while class VII- $_2$ (with 22 students) was a control class where learning was developed using traditional methods. In both classes, the same teaching units were teached, in the same environment, but with different teaching and methodological approaches.

3.1. Methods, procedures, and instruments for the research

The instruments that were used in this research for data collection are the following: pre-test, checklist and post-test that were used for both classes. The pretest was carried out in both classes with the same questions, to determine the level of knowledge of the students before applying the teaching based on experiments. The pre-test and post-test questions were the same for both classes, to check the prior knowledge the students poses (pre-test) and to evaluate the knowledge they have gained after the exposure to experiments (post-test). Through the checklist, notes were taken on the activity and abilities of the students for solving problems, their motivation and cooperation in the administration of the experiments. While the post-test was carried out after the administration of the experiments, and allowed the researcher to answers the questions and prove hypothesis of this study.

Experimental class	Control class
Learning with three modern methods	Traditional teaching
Experiment, research, integration and presentation of information.	We have not used additional research and information. We used only those that are presented in textbooks.
Giving additional experimental tasks at home and in the classroom.	I have not defined additional tasks.
Learning in groups.	The lesson is not carried out in groups.
Application of Experiments.	Learning theory.
Internet and other sources searched.	Dependence on the teacher.

Table 1. Changes in activities in control class and in experimental class

The table above (Table 1.) shows the activities that were used in both classes, in control and in experimental class. In the control class we presented the traditional teaching activities, while in the experimental class we presented teaching activities of the experimental (demonstration) method. In experimental class contemporary techniques have been used (experiments, demonstrations) that affected the learning of students, while control class implied only the traditional teaching technique. In the experimental class, through the teaching of every lesson, an experiment was developed with purpose to understand which method used there is showing higher results in the students' learning.

4. Results and discussion

From this research, we have achieved significant results in the students' learning performance and their interest in learning of the subject chemistry when they used experiment-based teaching. Also, this research has influenced teachers to use experimental method and modern techniques that will facilitate the teaching of natural sciences in general and the subject of chemistry in particular. From the indicated results of this research, it is noted that the positive

results that the students have benefited from the implementation of chemistry lessons with modern experimental methods, compared to the students of the first grade are notable.

In addition, findings from this research enabled us to understand featured skills of the students in solving experimental tasks which are related to their thinking skills, the creativity they have in giving new ideas and how they approach solving the problem. The application of the experimental based teaching in the lower secondary schools in Kosovo is of particular importance for the students, since with their help, students learn faster and easier, thus making the subject of chemistry more pleasant to the students.

4.1. Comparison of the results of the pre-tests of the control and experimental classes

In order to better understand the differences of teaching based on experiments compared to traditional teaching, through the relevant figures, we have presented the evaluation of students with grades. We provided these data for both the pre-test and the post-test. Below are presented the results from the answers of the students, from the control class and the experimental class.

The results of the pre-tests of the control and experimental class:

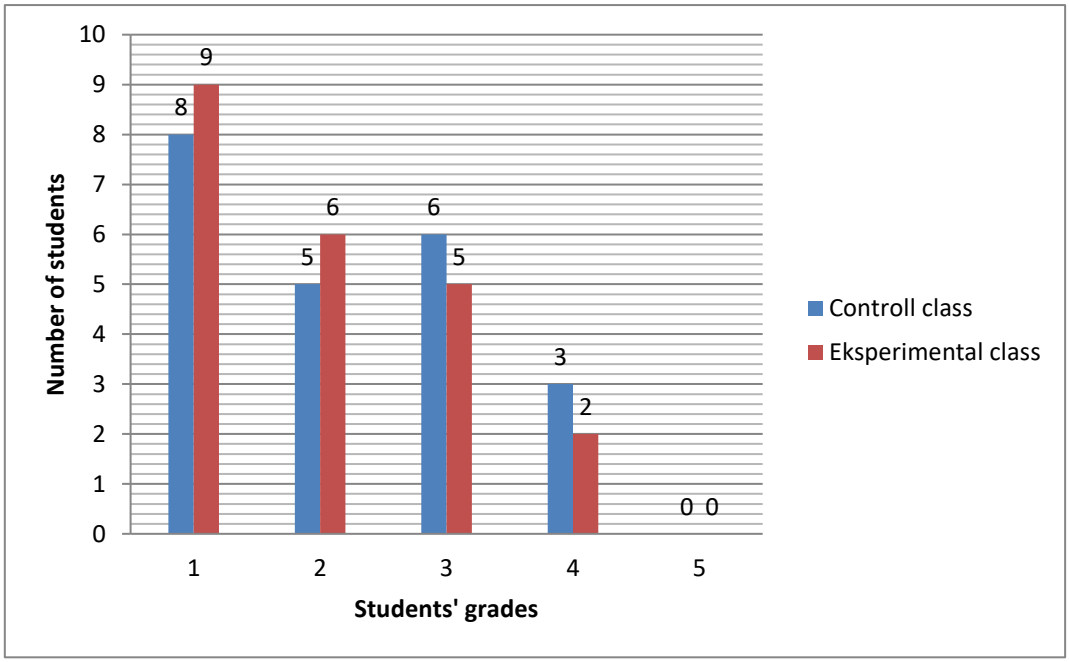


Figure 1. Comparison of the results in the pre-test between control class and experimental class

From the graph, it could be noticed that the control class, in the pretest of the learning units developed before the research, showed slightly higher results than the experimental class. So, the control class had slightly higher prior knowledge.

4.2. Comparison of post-tests results of control and experimental classes

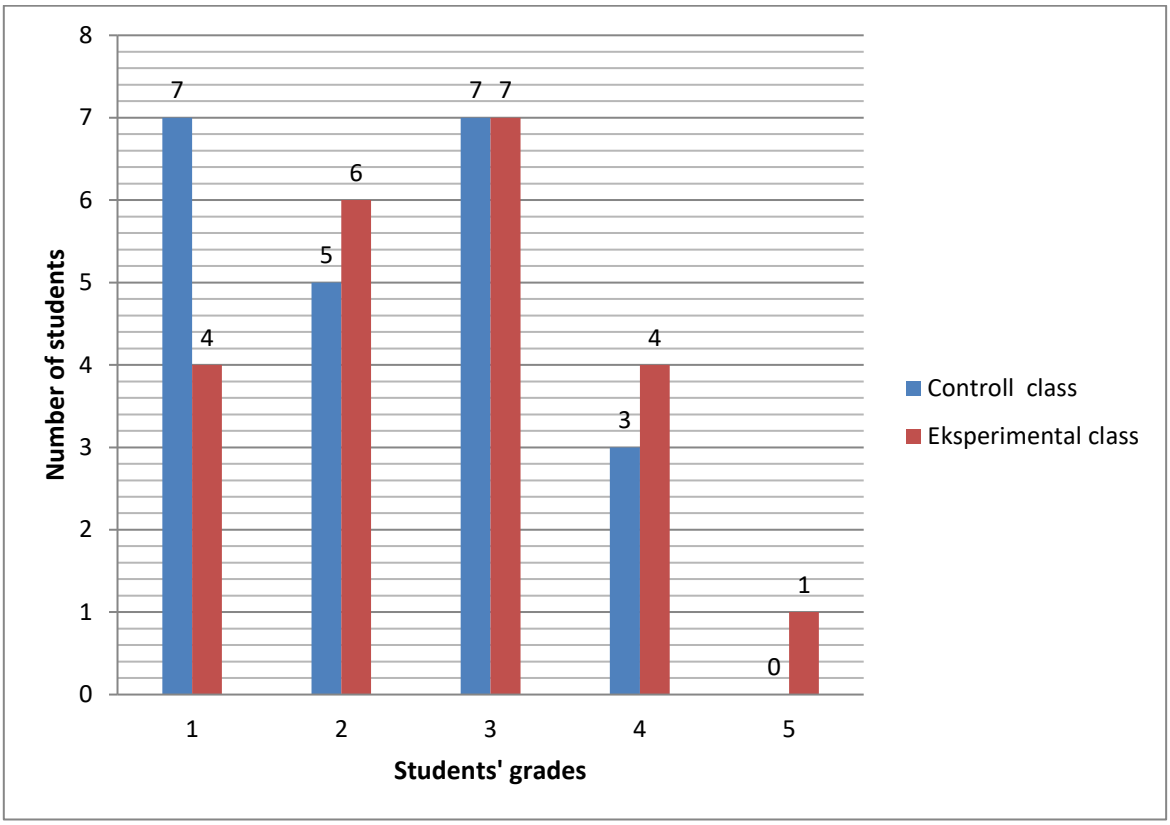


Figure 2. Comparison of results in post-test between control class and experimental class

In the graph, are presented the results of the students with the grades of the post-test from the teaching units realized after the research (intervention) was carried out. The learning units in the control class were teached through traditional teaching, while in the experimental class with teaching based on experiments. From the results of the post-test, it could be noted a difference between the control class and the experimental class. The experimental class, in this case, has better results than the control class. It should not be forgotten that the control class, in the pre-test, showed slightly higher results. The followed obtained results, in the experimental classroom, are believed to be indicated from the use of experiment-based teaching. From the data in Figure 2 it is noticed that the experimental class shows better results if we compare with the pre-test results. As seen here, the result is much higher. In this context, even when compared with the results with the control class, they are perceived as much higher.

These results are also supported by the results of the different studies in this field. In the study, regarding the levels of success achieved by the experimental group, the group that learned with experimental teaching methods, and the control group, which learned with traditional approach, a significant statistical difference is noticed in favor of the experimental group. This is an indication of the fact that teaching developed with based experiments contributed to student success more than teaching with the actual (traditional) curriculum, as it is stated in the contemporary findings regarding this problem (Pejchinovska, M., Kamchevska, B., 2016).

5. Conclusions and recommendations

The aim of this paper was to identify the impact of experiment-based teaching on the learning of the subject chemistry at the school level. Quasi-experimental method was used in the realization of this research. Based on the methodology procedures offered by this method, the study implied an experimental class, in which project-based teaching was developed, and a control class in which traditional teaching methods were developed. Through the use of pre-tests and post-tests, has been identified that experiment-based teaching promotes better results among students in the experimental classroom.

From the findings of the study, it is noted that the results of the post-test in the experimental class were better than in the control class. These positive results are believed to be related to the use of the experiments. In this regard, it appears that the experimental class was more successful than the control class. Therefore, it could be understood that the teaching based on experiments has positively influenced the results of learning the subject chemistry among the students of the seventh grades of the „Dardania" Lower Primary School in the Municipality of Pristina. The results of this study are also supported by the results of other researchers. According to the study of the authors Baert, Beunens, & Dekeyser (2002), teaching based on experiments influences students to learn with higher satisfaction and more easily. They asserted that teaching based on experiments can provide students with learning in the learning environment (Dekeyser, 2002).

According to Pawaits' study, (Pawait, 2019) it is indicated that that there is a significant difference in learning outcomes between the group of students who follow teaching based on practical experimental work and the group of students who follow learning through traditional methods. These changes are noted for the reason that learning, through experiments, creates students' critical and creative thinking skills. Students' teamwork through experiments, demonstrations, technologies and different materials affects student learning. Through the work in groups, the opportunity is created for the students to present their work as a team (Holubova, 2008).

Based on the review of the literature and the results of this research with seventh grade students, few important findings and recommendations have been compiled:

- The students of the „Dardania" school experienced for the first time teaching through the experimental method, an innovative method for them. Initially they had fears, emotions and doubts whether they would be capable of performing certain experiments by themselves and whether they would solve the problems that required solutions;

- From the testing through the post-tests, the students and teachers were satisfied with the results achieved and considering this fact, the teachers have expressed interest in continuing to use all modern methods such as experiments, demonstrations, projects during the teaching and learning process in the subject of chemistry;

- Inquiry based-teaching and learning is important to be promoted in the Kosovan education system; this approach might led to higher results in teaching science;

- To be successful, experiment-based teaching must be consistent with the curriculum of the relevant teaching unit in the subject of chemistry. It should be clear to everyone that the method is addressed to all the students in the class, a working group should be formed, the experiments, tools and basic literature should be selected so that the experiment or demonstration can be carried out more successfully to get as much information as possible and more precisely. For this purpose, the continuation of the use of the learning method

based on experiments will more often make positive contributions to the achievement of self-confidence and raising the results of students.

In general, the recommendations of this research are supported by other researchers, where according to Pupovci (2002) traditional framework of education was based on teacher-centered learning and memorization, and this outdated practice still continues in many cases. As a result, Kosovo ranks among the lowest among all countries participating in the PISA scientific test (OECD, 2016) with its results in science. Such low performance indicate that science teaching in Kosovo is inadequate and may result from poor performance of inquiry-based teaching and learning and/or active learning.

Thus, the most important characteristics of the application of experiments is to raise the success of students and make available new teaching methods, including the engagement of students and the implementation of the relevant methods, where students will be main actors of learning. The teacher must emphasize and clarify to the students that this teaching method offers them higher results in learning chemistry and in general success by raising their self-confidence and conviction that their work will be constantly evaluated during learning.

Students can improve their learning outcomes in chemistry if teachers make the subject more attractive by implementing experiments and showing concrete examples by engaging students as main actors in this process.

Teachers should choose suitable forms for creating the habit of experimental work of students. Teachers should look for ways to enrich their classes with means of concretization-eventually the regulation of chemistry laboratories. Students should be trained for practical laboratory work by conducting experiments and demonstrations. The task of the teacher is not only to teach but also to support his students, to motivate and increase their activity, their interest and willingness.

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