An Innovative Teaching Approach for the Unit “Acids-Bases-Salts”

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Abstract

This study presents an innovative teaching procedure in the field of chemistry in secondary education, in Greece, with an emphasis on the strategies used in the section of acids, bases and salts. While traditional pedagogical strategies hold the primary place in classrooms, their effectiveness in the enhancement of the knowledge of today's students and promoting deep understanding is increasingly challenged. The novelty of this study is that it proposes new and original teaching strategies (such as teaching through experiments, and workshops as a means of teaching, the use of videos during teaching, teaching through the project method and teaching with concept cartoons) that not only enhance understanding but also reinvigorate the educational experience for both students and teachers. Deep understanding of chemical reactions, bonds, structures, and the periodic table from teachers equips them with the necessary expertise to effectively convey complex concepts to students in a way that encourages understanding and critical thinking. The examination is an integral part in the context of teaching, conceptual animations can be used as a form of examination. Moreover, crossword exercises and tests require critical thinking on the part of the student rather than sterile memorization. In conclusion, the conduct of a chemistry course requires a course of instruction with the goal of capturing the student's interest in order to acquire the necessary knowledge.

Keywords: *acids, bases, salts, chemistry education*

1. Introduction

Acids, bases and salts are concepts in chemistry that serve as fundamental building blocks that underpin numerous chemical reactions and parallel effects. Understanding the properties, behaviours and interactions of these substances is essential to unraveling the complexity of chemical systems. Both for the microscopic world of molecular interactions and for the macroscopic processes that take place in everyday life. There are numerous examples of how the influence of these substances affects every aspect of human existence, such as the acidity of citrus fruits, the alkalinity of household cleaners, the buffering capacity of blood, the formation of metal deposits and many others
The terms "Acids and Bases" were first mentioned in 1884 when Svante Arrhenius, a Swedish chemist, introduced distinct classifications for the chemical compounds known as acids and bases. When these substances dissolve in water, they release ions into solution. According to Arrhenius, acids are defined as compounds or elements that release hydrogen ions (H^+) in solution, especially when dissolved in water. The Brønsted-Lowry theory, proposed independently by the Danish chemist Johannes Nicolaus Brønsted and the British chemist Thomas Martin Lowry in 1923, is a better understood concept of acids and bases. This theory provides a broader perspective compared to Arrhenius' theory, as it is not limited to aqueous solutions alone but extends to all systems containing protons. According to this theory, an acid is defined as a substance that donates a proton while a base is defined as a substance that accepts a proton. In a chemical reaction of acids and bases, an acid transfers a proton to a base, creating the corresponding coupled pairs of acids and bases. The definitions of protons, which were additionally proposed in the same year as Lewis' monograph, were introduced independently by Brønsted in Denmark and Lowry in England (Figure 1). The definitions of soluble systems have a more complex background. In their broadest sense, they recognize that changes in solvent cation-anion concentrations can occur either through solute dissociation mechanisms or through solute-induced solvation mechanisms. This concept is in line with the essence of Lewis's definitions, although the first explicit formulation of this definition is attributed in this way in a 1928 paper by Cady and Elsey [1].

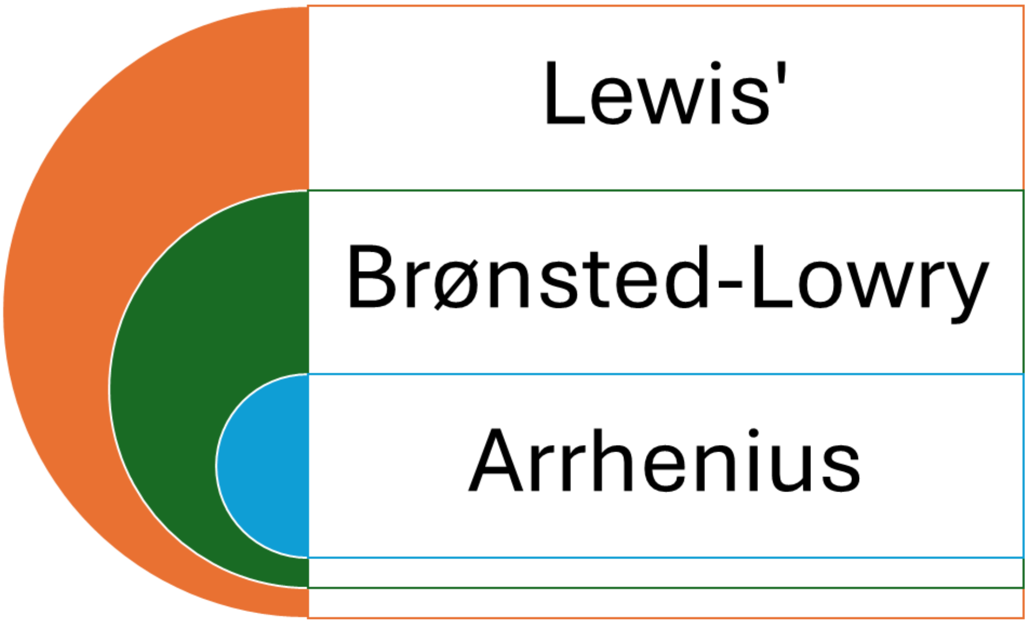


Fig. 1. The history of the "Acids and Bases"

Salts are compounds formed by the reaction of an acid and a base, where the hydrogen ion is replaced by the acid by a metal cation or other positive ion. These ionic compounds play different roles in nature, industry and everyday life.

The term "didactic" first appeared in the 17th century, attributed to Ratichio, and became known with Comenius' "Great Didactic" in 1657 [2]. From the time of Wilhelm Dilthey, didactics developed into a separate subfield. Didactics, synonymous with pedagogical teaching, include strategies used by teachers to facilitate learning. Didactics is defined as the discipline that focuses on the dissemination and enhancement of knowledge to strengthen the academic and sociocultural development of students (Saltas, 2009). In contemporary discourse, teaching is viewed as an exchange of educational content, with the teacher guiding students in knowledge acquisition and critical thinking. Moreover, teaching is seen as the application of pedagogical principles. It serves as a framework through which each discipline imparts basic knowledge tailored to its specific needs [3]. In addition, Atkins and Brown define teaching as providing learning opportunities for students. While this definition suggests activities such as reading and drama performances, they often include elements beyond the simple process of learning, complicating their classification as teaching [4].

Various theories of learning have been developed, the most important of which for science, and beyond, are: The behavioral learning theory, the reflective learning theory, and the constructivist learning theory [5].

The aim of this research is the knowledge construction as an emergent phenomenon, influenced by the interactions of the context. It emphasizes the development of strategic learning methods and the development of scientific inquiry skills, enabling students to adopt a scientist's mindset. Through guided instruction, students uncover scientific content, including interpretation of phenomena and understanding of fundamental principles. The novelty teaching strategy is influenced by two main factors. First, the need for students to interact with real objects leads to teamwork in classrooms for effective resource management. Second, the organization of classes into groups poses challenges for direct teacher-student communication, thus necessitating the use of instructional worksheets. Acutely aware of these conceptual landscapes not only enables teachers to design activities that foster students' understanding, but also cultivates a fertile ground for voluntarily relinquishing preconceived notions in favor of scientifically grounded perspectives.

2. Strategy and Methods

In this research, a fundamental reconfiguration of teaching and assessment methods are proposed. The integration of interactive and experiential learning methods is advocated, utilizing a variety of resources, experimental learning, and collaborative activities to explain the detailed principles that dominate in acids, bases, and salts, such as teaching through experiments, and workshops as a means of teaching, the use of videos during teaching, teaching through the project method and teaching with concept cartoons.

The teacher must follow a tactic so that the student develops his skills, consolidates the knowledge given to him, and conquers 'learning'. In the subject of chemistry, the teacher has the possibility, in addition to the traditional teaching methods, to approach the subject through various supervisory means, such as conducting experiments, slides, pictures, and videos [6]. More specifically, the teaching of the thematic cycle "ACIDS-BASES-SALTS", is an important part of learning experience in chemistry as teaching concepts. Through the study of these chemical groups, students understand the basic principles of acidity and alkalinity, as well as the importance of salts in everyday life and industry. Through experiments and theoretical analysis, students explore the properties and applications of these chemicals, fostering critical thinking and problem-solving. To be effective, their teaching needs to be carried out in a specific context, which requires collaboration between students and teachers.

Integrating experimentation into the teaching process paves the way for a more experimental and active approach to learning. This process encourages collaborative learning, where students can exchange ideas and act as a team through experimentation. At the same time, the focus of the learning process is on understanding and applying theoretical knowledge to real-life situations, giving students the opportunity to explore the concepts of acids, bases and salts through practice. In this way, the learning process is made more exciting and interesting, while at the same time enhancing students' confidence in their abilities.

Textbooks suggest experiments with materials that are easily accessible to students and teachers, such as lemon, ammonia and window cleaner. This enables students to explore chemical interactions in a friendly environment. Adding lemon to tea or baking soda has interesting effects, due to the citric acid in the lemon, such as changing the color of the drink or producing foam. These interactions are classic examples of chemical reactions that can be observed with everyday materials. As far as the addition of an indicator to solutions such as ammonia or glass cleaner is concerned, this can lead to color changes due to the chemical reaction between the indicator and the solution.

In addition, the teacher in collaboration with the school unit and a university institution have the ability to organize excursions to equipped laboratories, since such laboratories and reagents are usually not available in school structures. This offers a unique opportunity for students to extend their knowledge beyond the confines of the classroom and to have a real educational experience. During these field trips, students come into contact with real laboratory environments and have the opportunity to see an experiment being carried out. In addition, they have the opportunity to talk with under gratuade and post graduate students who can offer more information about acid, base and salt compounds, their reactions and uses, and the dangers they pose.

The project method helps students as they research, exchange knowledge and experiences, and design the experiment in the specific case they are studying. This process enhances the depth of learning and the acquisition of skills. In the end, they present their conclusions to the rest of the class and the professor, who provides feedback. After the experiment, students tackle the theoretical analysis of it, which gives them the best possible understanding of the lesson.

This process closely resembles a combination of what Piaget refers to as the Constructivist Model of Teaching and what Bruner identifies as Discovery or Inquiry-Based Learning. On one hand, students construct new knowledge from existing knowledge as they connect their actions with previous ones through active participation in experiences and problems (experiment), creating a learning continuum. On the other hand, they are encouraged to discover knowledge through interactive tasks and experiments. This second approach focuses on self-solving, active participation, and the development of critical thinking, thereby promoting deeper understanding and comprehension of the subjects and issues at hand [7].

In case the class lacks the appropriate equipment and environment or cannot support collaboration with an external laboratory, such as a university, the professor can use audiovisual experiments from the internet for teaching [8].

Video projection of chemical experiments in the classroom is an important part of the modern educational process, bringing revolutionary benefits for students and teachers alike. One of the main benefits of video projection is the visual representation of the experiments. Often, the abstract description of an experiment can be difficult for students to understand. Video provides a realistic picture of the process and results, allowing students to understand more easily the scientific phenomena presented. Also, safety is a primary concern in any educational environment. With the use of videos, students can observe experiments that might be dangerous or difficult to control in a classroom. This ensures their complete safety without the risk of a potential accident. In addition, the ability to access the videos at any time is critical for continuous learning. Students can repeat experiments whenever they wish, thus enhancing their understanding and ensuring that no one is left behind in the learning process.

Finally, the videos not only provide an insight into the experiments, but also a platform for educational discussion. The teacher can use these videos as a basis for extending the discussion to applications, implications, and future extensions of the scientific principles being discussed (Figure 2). As a whole, the videos on chemical experiments push the boundaries of the educational process, encouraging students' active participation and understanding in a world of scientific discoveries and developments.

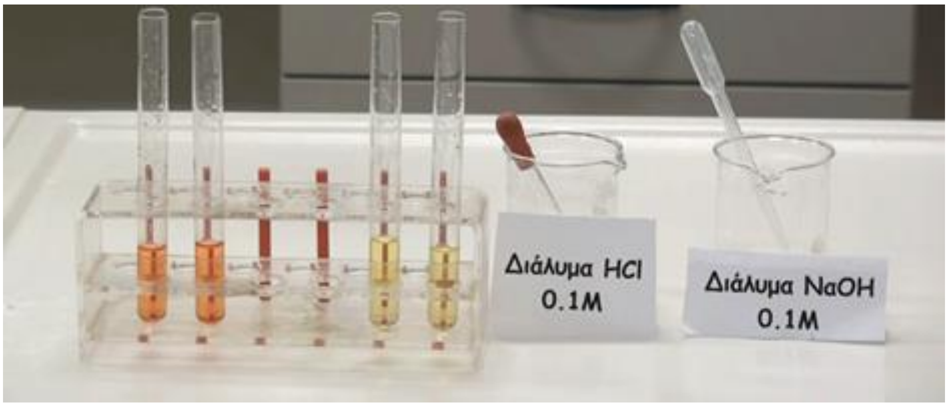


Fig. 2. Resistance of indicator color change due to presence of buffer solution

Another way of alternative teaching is the use of concept cartoons. This idea was originated by Stuart Naylor and Brenda Keogh in 1991 [9] with the intention that they are effective because they are based on everyday situations, making science less intimidating and more engaging for students [10]. They are flexible to different cultures, presenting a variety of viewpoints, including those that are scientifically accepted. With empty inflatable speech balloons, they encourage exploration of alternative ideas. The language used is student-friendly, allowing for independent use. All opinions are considered equivalent, helping less confident students to express their thoughts. Common misconceptions are addressed directly, based on research evidence of students' ideas at different age.

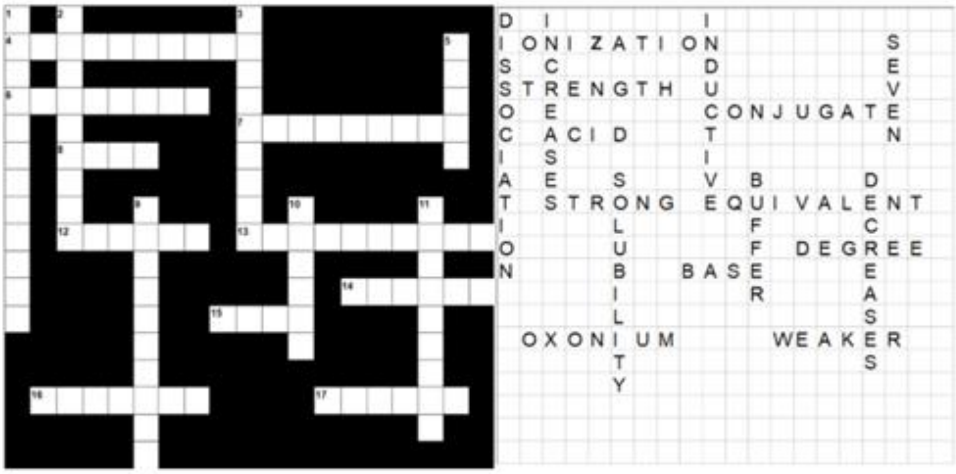
3. Results and Discussion

In the context of teaching, an integral part is the examination. The need for innovative examination methods in the field of chemistry is paramount to ensure effective student understanding. Traditional examinations may not fully reflect students' actual understanding and skills in this area. It is therefore necessary to seek new approaches that will allow teachers to assess students' progress in a more comprehensive way.

Moreover, crossword exercises and tests require critical thinking on the part of the student rather than sterile memorisation. A crossword puzzle, in addition to the theoretical background, can also test the practical part of chemistry. For example, the details of an experiment, the uses and dangers of acids, the applications of bases in everyday life, or how salts are produced by the neutralization of an acid and a base (figure 3).

In addition, the use of technology and interactive platforms can enable teachers to assess students' knowledge in a more dynamic way. This can include interactive exercises, games and simulations that allow students to demonstrate their knowledge in a fun way (true-false exercises and matching exercises). In the true-false questions, a √ is marked to the right of the correct answer. If students answer incorrectly, an explanation follows to help them understand their mistake (figure 4), while in the matching exercises each concept listed in the left column corresponds to one in the right column. The correct answers are listed on the right and at the bottom (figure 5).

To compare the effectiveness of the traditional educational method with the presented strategy a comparison between the two pedagogical strategies has been realized. More specifically, the 62 students at Aristotle College of Thessaloniki were divided into two groups. The two groups answered the question if the educational material helped them to understand the unit “Acids-Bases-Salts”. Figure 6 shows the result. In the traditional educational method, only half of the students are satisfied while adopting the new innovative teaching, the satisfaction percentage is considerable higher which indicates that the new educational material is evaluated with high importance by the students.



Statements:

Vertically:

1.The term ____________ describes the removal of ions from the crystal lattice in ionic compounds.

2.In a given group of the periodic table, the strength of acids _________ from top to bottom, as the atomic radius of the element bonded to hydrogen increases.

3.The shift of electrons in a bond due to the presence of neighboring group of atoms is called _________ effect.

5.The pH value of pure water at 25°C is _____.

9.__________ of a substance is the maximum amount of the substance that can dissolve in a given amount of solvent, at a specific temperature.

10.______ are the solutions whose pH remains practically stable when a small but measurable amount of strong acids and bases is added.

11.If in an acidic solution we add pure acid and the volume of the solution remains constant, the pH _________.

Horizontally:

4.__________ of a covalent compound is the reaction of its molecules with molecules of the solvent (water), to form ions.

6.Value of K_a and K_b is a measure of the ________ of the acid or base, for a given temperature.

7.In the reaction: $A^- + H^+ \rightarrow HA$, the pair HA and A^- is called _________ pair.

8.According to Arrhenius theory, any hydrogen compound that when dissolved in water will give H^+ is called ____.

12.______ acids ionize completely in water.

13.The point of titration where the substance has fully (stoichiometrically) reacted with a certain amount of standard solution is called __________.

14.The ______ of ionization of an electrolyte (α) is defined as the ratio of the number of moles that ionize to the total number of moles of the electrolyte.

15.According to Brønsted-Lowry theory, the substance that can accept one or more protons is called ____.

16.pH is defined as the negative decimal logarithm of the concentration of _______ ions in an aqueous solution.

17.In acid-base reactions, the equilibrium shifts towards the ______ acid and the weaker base.

Fig. 3. Crossword exercises

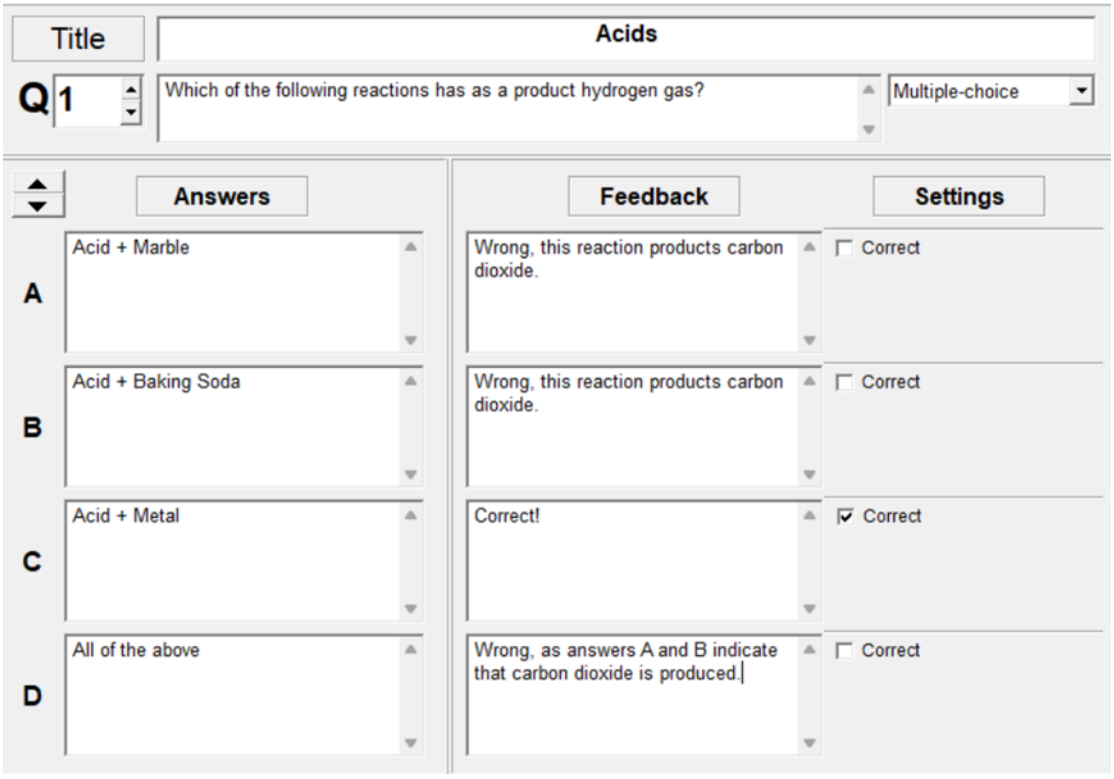


Fig. 4. True-False example question

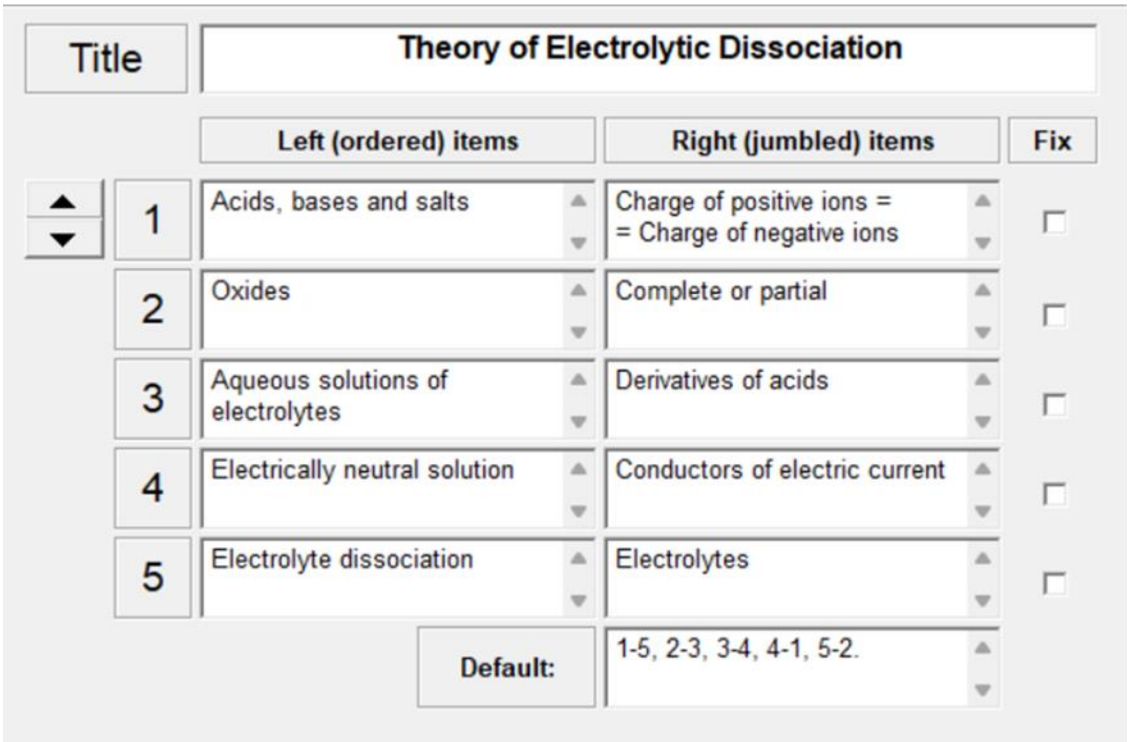


Fig. 5. Matching exercises example question

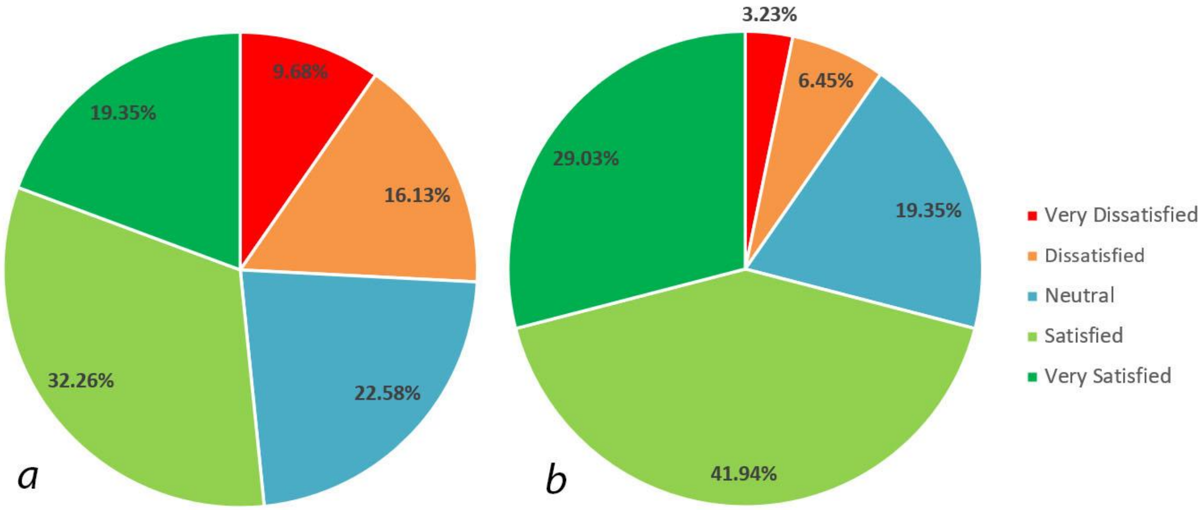


Fig. 6. Satisfaction percentage of students a. with the traditional educational method and b with the innovative teaching approach

4. Conclusion

The innovative teaching methods were designed and developed with the main objective of correlating the culture of everyday life of students with that of science. It is an innovative analysis effort aimed at resolving misconceptions that promote curiosity and encourage the desire of learners to investigate and discover the mechanisms that lead to the development and evolution of natural phenomena. The possibilities of visualizing a simple demonstration of motion phenomena are clearly also limited by the texture of the phenomena under study. The typical space of their observation (a science laboratory) does not allow, for example, the connection of natural sciences with everyday life. The potential learning benefits of the didactic use of the present directly depend on both the teaching strategy of the teacher and the teaching objectives that he/she sets each time. The conclusions that emerged are encouraging in terms of the students' ability to interpret, with the help of the visualizations of the microcosm contained in the innovative strategies teaching methods, the role of chemical processes in the creation and evolution of the phenomenon and even to understand the role of certain reactions.

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