Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.15, No.2, 2024 

# Exploration and practical reforms of inorganic chemistry experimental teaching in normal universities

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*The research is financed by the Yancheng Teachers University Start-Up Research Fund (No. 204060041), the Science and Technology Project of Yancheng City (No. YCBK2023056), the Education and Teaching Reform Project of Yancheng Teachers University (Nos. 2023YCTCJGZ07, 2023YCTCJGY23).*

**Abstract**

Recognizing the challenges inherent in traditional inorganic chemistry experiment, a comprehensive reform has been implemented in the teaching of inorganic chemistry experiments. This reform encompasses various aspects, including experimental safety, teaching methods, teaching system, assessment mechanism and environmental protection. Aligned with the unique characteristics and educational objectives of chemistry majors in normal colleges and universities, this initiative aims to enhance students' overall qualities. As a result of these reforms, there has been a notable improvement in students' interest in learning, foundational skills in experimental operations, and their overall scientific aptitude. This holistic enhancement has not only elevated students' comprehensive capabilities but has also contributed to an overall improvement in the quality of chemical experiment teaching.

**Keywords:** Experimental teaching reform; Inorganic chemistry experiments; Exploration and practice, Normal university

**DOI**: 10.7176/JEP/15-2-08

**Publication date**: February 28th 2024

The aim of reforming inorganic chemistry experimental teaching is to establish a modernized model that aligns teaching content, methods, and approaches with contemporary standards, fostering progress, diversity, and modernity. Recognizing the limitations of traditional inorganic chemistry experimental teaching in normal universities, efforts are directed towards designing a new inorganic chemistry experimental teaching system tailored for freshmen in these institutions. This endeavor seeks to enhance the quality of experimental teaching, instill a keen interest in learning, and develop fundamental experimental operation skills among students. The goal is to play a pivotal role in correcting scientific attitudes, shaping outlooks on life, and influencing values positively.

## 1. Challenges present in the inorganic chemistry experimental teaching at normal universities

### 1.1 Insufficient awareness of security

The insufficient awareness of security in inorganic chemistry at the university level poses a critical concern for the well-being of students and the overall integrity of laboratory practices [1]. During the summer, some students, seeking comfort and convenience, enter the laboratory wearing shorts, skirts, sandals, etc., unaware that this constitutes a serious violation of laboratory rules and regulations. Despite teachers providing safety education and training before students engage in experiments, there are cases where students still do not give it adequate attention. There is a prevailing belief that basic experiments selected by teachers are inherently safe, leading some students to underestimate the potential risks. This attitude, however, can result in serious consequences during emergencies, as students may become nervous and handle problems incorrectly, leading to more significant accidents.

### 1.2 Lack of diversity in teaching models

The traditional and common teaching model in experimental teaching, known as "Tell first and then do" is limited in its effectiveness. This singular approach, along with the "hands-on teaching" experimental method, primarily serves the purpose of experiment verification. Unfortunately, it falls short in fostering students' scientific understanding [2]. More importantly, it inhibits the development of innovative thinking and overall capabilities. In this model, students heavily rely on instructors or textbooks during experiments and often struggle to conduct experiments independently. For instance, when faced with challenges such as the alkaline solution not dripping out of the burette while squeezing the ball, many students tend to seek immediate assistance from the teacher instead of analyzing and solving the problem on their own. This dependency hinders the cultivation of independent problem-solving skills.

1.3 The experimental material is antiquated and redundant, with an irrational arrangement of the curriculum

The content of conventional inorganic chemistry experiments is outdated, necessitating appropriate adjustments to align with current trends in chemical development. The predominant focus on basic operations and confirmatory test tube experiments, constituting over 90% of total inorganic chemistry experiment hours, particularly includes numerous confirmatory test tube experiments [3]. These exercises involve simple operations and fail to adequately train students in experimental techniques. Additionally, there is redundancy in some inorganic experiment content, which overlaps with experiments in other subjects and even replicates certain confirmatory experiments taught at the secondary school level. This organizational approach results in a squandering of resources and time, rendering it unnecessary. Furthermore, the course schedule displays a lack of coherence, with the pace of experimental classes outpacing that of theoretical classes. Consequently, experiments commence before the corresponding theoretical content is covered, leaving students without the necessary theoretical guidance during their practical work, forcing them to proceed blindly and mechanically.

1.4 The experimental assessment mechanism is not rigorous

The experimental assessment mechanism employed in inorganic chemistry experiments lacks a robust and rigorous framework [4]. Currently, students' daily performance primarily relied on the evaluation of their experimental reports. This gave rise to a situation where some students did not approach the experiments with seriousness but still obtained high grades. The overreliance on this single evaluation metric may inadvertently contribute to a disconnect between the grades awarded and the actual level of understanding and commitment demonstrated by students during the experimental process. This system not only runs the risk of rewarding superficial efforts but also fails to capture the nuances of individual engagement, critical thinking, and hands-on skills that are integral to a comprehensive understanding of inorganic chemistry experiments. Consequently, a more multifaceted and holistic assessment approach is imperative to provide a fair and accurate representation of students' overall performance in the realm of experimental work.

1.5 Poor awareness of environmental protection

There is a notable deficiency in environmental protection awareness during inorganic chemistry experiments. Inorganic chemistry experiments, especially elemental chemistry experiments, require many types of reagents, resulting in a lot of waste gas and liquid [5]. During the experiment, some students did not pay attention to details, used a large amount of solid and liquid reagents, and discarded the products and waste liquid generated during the experiment casually. This in turn causes great harm to the human body and the environment. Chemical waste disposal, energy consumption, and resource utilization are areas where a heightened environmental consciousness is crucial. Enhancing awareness and integrating eco-friendly practices into inorganic chemistry experiments is imperative to mitigate the environmental footprint associated with these activities.

## 2. Reflections on the revitalization of inorganic chemistry experimental teaching

2.1 Systematic enhancement of experimental safety

When students engage in experimental activities, the concentration of personnel increases, and safety risks accumulate. It is of utmost importance to provide precise training for student participation in experimental sessions. To address this concern, we have incorporated safety education into the teaching plan and experimental syllabus, creating a comprehensive and systematic laboratory safety education and training system. When it comes to granting laboratory access, our approach extends beyond examinations and signed commitment letters. Specifically, we emphasize targeted and specialized safety training tailored to the characteristics of chemistry and biological safety. Essential laboratory safety knowledge is integrated into the compulsory curriculum of each school's general education system, ensuring that students must pass the study assessment to qualify for course selection. Failure in the assessment renders them ineligible for course enrollment. Furthermore, emergency drills and seminars are employed to reinforce safety concepts and practices among students.

2.2 Clarify the purpose of experimental course teaching and reform experimental teaching methods

 

Articulating the objectives of experimental course instruction and revitalizing teaching methodologies are pivotal endeavors in the pursuit of educational enhancement. Through systematic study, incoming first-year students can progressively acquaint themselves with the fundamental knowledge of chemical experiments and basic operational skills in inorganic chemical experiments. This facilitates their acquisition of perceptual knowledge related to numerous material transformations. In accomplishing the teaching objectives of inorganic chemistry experiments, both educators and learners must actively collaborate to achieve a mutually beneficial "win-win" situation. Teachers serve as mentors, inspiring the development of students' critical thinking skills. It is imperative for students to comprehend the fundamental operations of inorganic experiments, forming the groundwork for advanced experiments and future mastery of novel experimental techniques. In each experiment, theoretical understanding should be coupled with rigorous training in basic operations, emphasizing the importance of standardized procedures. Therefore, educators should consistently underscore the significance of experimental courses in teaching and clarify their instructional objectives. This commitment is paramount for the construction and effective delivery of experimental courses.

2.3 Optimize experimental content and update experimental course teaching system

Considering the historical context, there has been an observed discrepancy in the pace of progress between theoretical courses and inorganic chemistry experimental courses. Notably, the prevalence of confirmatory test tube experiments has been disproportionately high, with a conspicuous absence of exploratory experiments. In response to these challenges, recent years have witnessed a proactive approach towards optimization and integration of traditional inorganic chemistry experimental content. This process involved a meticulous examination of experimental syllabi from other institutions and an extensive literature review. The reform initiatives have been twofold: firstly, elevating the proportion of basic operational experiments, and secondly, augmenting the share of comprehensive and design experiments. These strategic adjustments aim to harmonize the balance between theoretical and practical components, fostering a more dynamic and explorative learning environment within inorganic chemistry experimental courses. Furthermore, we are committed to updating the experimental course teaching system, employing innovative pedagogical techniques, and leveraging technology to foster a dynamic and engaging learning environment. This holistic approach aims not only to deepen students' theoretical understanding but also to cultivate practical skills, critical thinking, and adaptability, ensuring that our experimental courses remain at the forefront of educational excellence.

2.4 Establishing an innovative experimental assessment mechanism

Pioneering the development of an innovative experimental assessment mechanism involves a strategic and forward-thinking approach to evaluate students' performance in experimental courses. As a result, the semester experiment's overall score has been bifurcated into two components: regular grades, constituting 60% of the total, and final exam scores, comprising the remaining 40%. As part of the ongoing reform in inorganic chemistry experimental teaching, there has been a deliberate reduction in the weightage assigned to experimental reports within the overall experimental grades. Recognizing the fundamental nature and extensive content of inorganic chemistry experiments, a meticulous and timely evaluation of each experiment has been implemented to assess students' experimental proficiency. The outcomes of these evaluations serve as students' routine scores. To facilitate this, a comprehensive record-keeping system has been introduced, presenting a table where daily attendance performance contributes 5%, preview report accounts for 10%, experimental report holds a 15% weightage, and basic operations carry a substantial 30%. The adoption of this new experimental assessment system endeavors to render the evaluation process more rational, equitable, and scientifically sound, thereby enhancing the overall effectiveness of the assessment.

2.5 Reinforcing the principles of green chemistry and advocating for the adoption of miniaturized experiments

Enforcing the fundamental tenets of green chemistry and actively endorsing the incorporation of miniaturized experiments stand as pivotal initiatives in our commitment to sustainable and eco-friendly laboratory practices. By embracing the principles of green chemistry, we prioritize the reduction of hazardous substances, waste generation, and overall environmental impact in our experimental procedures. This approach involves the selection of greener solvents, the promotion of energy-efficient methodologies, and the exploration of alternative, environmentally friendly reagents. Concurrently, the advocacy for miniaturized experiments aims to further minimize resource consumption, reduce chemical waste, and enhance the overall efficiency of laboratory operations. These combined efforts underscore our dedication to cultivating an environmentally conscious mindset among students and fostering responsible practices within the realm of experimental chemistry.

 

## 3.Conclusion

Over the course of numerous years in inorganic chemistry experimental teaching, we have actively pursued the development of a novel teaching system tailored for freshmen in normal colleges and universities. This comprehensive initiative encompassed reforms in experimental safety, teaching methodologies, content delivery, teaching systems, the assessment mechanism, along with an emphasis on cultivating students' environmental awareness. These multifaceted improvements have yielded commendable results, marked by enhanced student engagement, improved foundational experimental skills, heightened proficiency in problem analysis and resolution, enhanced innovation capabilities, and an overall elevation in scientific acumen. As educators in higher education, it remains imperative for us to continually enhance our professional and technical expertise, as well as our pedagogical proficiency, ensuring a sustained commitment to advancing the quality of chemical experiment teaching in the future.

## Acknowledges

The research is financed by the Yancheng Teachers University Start-Up Research Fund (No. 204060041), the Science and Technology Project of Yancheng City (No. YCBK2023056), the Education and Teaching Reform Project of Yancheng Teachers University (Nos. 2023YCTCJGZ07, 2023YCTCJGY23).

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