2025 Volume 3, Issue 1
Lecture Notes in Education, Arts, Management and Social Science
ISSN(Online): 2705-053X

A Brief Discussion on "Applying Reality to Reason" in Inorganic Chemistry under the Background of Big Data Digital Age

Yanling Wu*, Tong Lu, Qian Tang, Xinlei Zheng
College of Transportation and Civil Engineering, Shandong Jiaotong University, Jinan Shandong 250357

***Corresponding author:** Yanling Wu, zsgz@sdjtu.edu.cn

Abstract:

With the continuous development of science and technology, the era of intelligent digitalization is also advancing, and the digitalization of education is also constantly following up. The experimental teaching part of "Inorganic Chemistry" is also deepening the dynamic curriculum goal of "giving reality to reason" because of the enabling role of intelligent teaching. In the exploration and reform of many educational practices, it was believed that the combination of theory and experiment innovation, innovation and intelligence can become an effective way to upgrade quality education.

Keywords:

Inorganic chemistry
Chemical equilibrium
Innovative combination of theory and experiment
Pragmatic
Innovation complemented by intelligence

Online publication: February 7, 2025

1. Introduction

Inorganic Chemistry is the civil engineering major represented by the majority of efficient students from "secondary school chemistry" to "university chemistry" transition "enlightenment discipline," and inorganic chemistry has a strong modern characteristics, both differentiation and synthesis, therefore, discussing inorganic chemistry has become the majority of university education researchers to explore, practice, optimization and reform one of the important objects.

With the national major strategic deployment of "Made in China 2025," "networking +" and "The Belt and Road," as well as the vigorous development of new industries and new economies characterized by intelligence, information technology and digitalization, new and higher requirements have been put forward for the training of talents in higher education. To this end, China's higher education actively promotes the construction of "new engineering," and has successively carried out and reached the "Fudan Consensus," "Tian Da Action" and "Beijing Guide" and other consensus, and strives to explore and lead the Chinese experience and Chinese model of engineering education in the world, and help the construction of a powerful higher

education country [1,2].

In the context of the continuous development of big data digitization, the continuous introduction of new intelligent models, educational methods, teaching content, and educational means are constantly innovated imperceptibly. The product of the intelligent digital era is expected to become a helpful assistant in the teaching of Inorganic Chemistry. However, most teachers are not familiar with intelligent teaching and have relatively professional information technology application ability, which means that even if teachers can realize that intelligent teaching means have positive teaching significance for curriculum reform, it is also difficult to effectively apply the corresponding teaching expression flexibly into the curriculum, and then achieve the development purpose of educating people by virtue and diversified teaching [3]. In the teaching of Inorganic Chemistry, teachers are not only the imparts of knowledge, but also become the organizers and planners of the classroom. Teachers can create exclusive teaching content for each student with rich teaching materials and contents through artificial intelligence-assisted teaching and virtual interaction, to make the idealized teaching of "one person and many teachers" possible and deepen the "teaching according to student's ability." However, every coin has two sides. For example, universities have different opinions on the application of ChatGPT in education [4]. Therefore, ways to flexibly, efficiently and dialectically use the handy tools endowed by the big digital age is the key to the upgrading of quality education.

2. The design and framework construction of the curriculum guidance program

Under the background of the digital era of big data, the traditional teaching model is no longer suitable for the development and training needs of modern talents. With the rise and development of new technologies, teaching methods are being "welcomed" step by step, especially digital applications, such as the flipped classroom, micro-teaching assistant, rain classroom and other emerging methods that are very popular among educators and education researchers. Digital teaching resources refer to digital processing, can be run on the multimedia computer or network environment, and can realize the shared multimedia teaching materials [5].

2.1. Course design method

2.1.1. The combination of online guidance and teacher-led teaching

Before class, teachers release online preview guide teaching or "pre-class guide" and preview videos through online software such as Rain Classm to help students grasp the preview task and the outline of the course as a whole, and think about ways to solve problems and achieve learning goals, to build an experiment framework before the experiment. In class, the teacher introduces the curriculum objectives and experiment planning and briefly summarizes the core knowledge, operation process, operation skills and expected results of the experiment. Students are free to form teams and explore independently, combined with the teacher's face-to-face guidance, and finally form a method and system to solve the problem. After class, the students design the mind map, such as the summary of the experimental content, results and error analysis and the combination of theory and experiment, etc., timely summary and reflection of the problem-solving process, innovative design, improve the program, expand the research, to achieve the systematic, structured, drawing an analogy effect.

2.1.2. Experiment teaching

Teachers adopt experimental teaching with student inquiry as the main form. Teachers cultivate students' independent learning ability of "independent preview, independent experiment and independent reflection" through the way of students' inquiry so that students can actively and spontaneously improve their ability to think, solve and examine problems. In the course of the guided study, teachers can appropriately design clever "traps" when setting questions, to cultivate students' questioning spirit and dig out their serious and practical research style.

2.2. Example of course design process - Chemical balance

2.2.1. Dig according to demand

Before the beginning of the course, reasonable and feasible teaching content should be selected according to the course needs, training objectives, and existing conditions of chemical balance. Taking the chemical equilibrium in the inorganic chemistry textbook as an example, based on learning the mass relationship and energy relationship in the chemical reaction, the three problems of the direction, rate and limit of chemical reaction are discussed emphatically. The theoretical concepts of equilibrium constant, activation energy, Gibbs free energy change of reaction, and entropy change of reaction in this chapter are used to solve the above three problems.

2.2.2. Guided design

Through online teaching platforms (such as Rain Class, micro-teaching assistant, etc.), teachers send course tasks and situational data in specific backgrounds to students, and set questions according to the corresponding scenarios: What is the spontaneous process? What are some examples of spontaneous processes in our daily lives? What are the effects of catalysts on chemical reactions? What are the applications of catalysts in production and life and in inorganic chemistry experiments? What are the factors that affect the rate of chemical reaction? What are the effects of chemical balance on production and life? What are the factors that affect the movement of balance?

The essence of the design of these questions is to let students with questions and tasks, independent learning online teaching platform-related resources, and to stimulate students to explore the interest of complicated questions and explore the ability of students to explore the unknown. For the questions that students find difficult to understand, teachers use the form of open online Q&A to discuss and communicate. According to the situation of the students, the teacher makes a preliminary assessment to determine the direction of topic selection, asks students to aim at one of the directions, and designs feasible experiment methods and schemes for the topic.

2.2.3. Experiment conception and experiment report writing

Change a factor acting on the equilibrium system, the equilibrium will produce a corresponding shift. If the reactants or/and products are colored or precipitated, the equilibrium shift can be "observed" depending on the color change and the amount of precipitation. The teacher presupposes the experiment, and the students conduct their experimental exploration mainly in the form of group cooperation. The experimental reagents are as follows:

(1) Methyl orange is yellow in a base solution, whereas the transition color is orange, and red in an acid solution.

(2) Orange-red $Cr_2O_7^{2-}$ and yellow CrO_4^{2-} are balanced by H^+.

$2\ CrO_4^{2-} + 2\ H^+ <=> Cr_2O_7^{2-} + H_2O$

Experiment selection case: Experiments 1–2 take a colored body as an example to illustrate the balance shift. Chemical equilibrium and its movement is a universal law, and whether the type body has characteristic color is not important. Experiment 3 is another typical example.

(1) Add 30 L potassium chromate (K_2CrO_4, 0.1 mol/L) solution to each of the 6 clean test tubes. Test tube 1 was used as the control group. 3, 5, 9, 13, and 17 drops of 1 mol/L sulfuric acid solution were added successively in test tubes 2–6 and mixed well. The orange color indicated that the solution contained two types of CrO_4^{2-} and $Cr_2O_7^{2-}$. It is observed that the color in these test tubes is from yellow to orange-red, but the color change time is not the same. It follows that there must be a small amount of $Cr_2O_7^{2-}$ or CrO_4^{2-} in the yellow or orange-red solution.

(2) Adding $K_2C_2O_7$ solution to $Pb(NO_3)_2$ and $Ba(NO_3)_2$ solution, it is observed that yellow $PbCrO_4$(Ksp~10-13) and $BaCrO_4$(Ksp~10-10) are precipitated in the solution; Drop K_2CrO_4 solution into $Pb(NO_3)_2$, $Ba(NO_3)_2$ solution, and observe that yellow $PbCrO_4$ and $BaCrO_4$ precipitate in the solution. In the second experiment, yellow precipitates were also observed, which indicated that the $K_2C_2O_7$ solution contained CrO_4^{2-} type bodies. Since the content of CrO_4^{2-} in $Cr_2O_7^{2-}$ solution is small and the concentration is not large, it only meets the requirements of the precipitation of less soluble chromates, and does not meet the requirements of the precipitation of chromates whose solubility is not difficult to dissolve (such as $SrCrO_4$, Ksp~10-5).

(3) Add $BaCl_2$ solution to 0.1 mol/L $H_2C_2O_4$

solution to obtain white barium oxalate precipitation; $CuSO_4$ solution was added to 0.1 mol/L H_2S solution to immediately obtain black copper sulfide precipitation. Why can precipitate be formed and why can precipitate be formed immediately in the second experiment?

Through a series of calculations, it can be seen that the concentration of 0.1 mol/L $H_2C_2O_4$ solution and H_2S solution is slightly less than 10-5 mol/L and 10-13 mol/L. Therefore, $Ba(NO_3)_2$ solution is added to the $H_2C_2O_4$ solution to obtain white BaC_2O_4(Ksp~10-7) precipitation, which is consistent with both theoretical estimation and experimental phenomenon. Theoretically, when $CuSO_4$ is added, a precipitating reaction occurs immediately, and only a very small amount of copper sulfide (Ksp~10-36) is formed. However, before adding cupric sulfate solution, the concentration of S^{2-} in H_2S solution is only 10-3 mol/L, while the experimental phenomenon is that when $CuSO_4$ solution is dropped, an obvious amount of CuS is immediately produced.

When CuS formed in the solution and BaC_2O_4 precipitated, the pH of the solution gradually decreased, and the concentration of S^{2-} and $C_2O_4^{2-}$ in the solution also gradually decreased. If the solubility of precipitation is small enough, when CuS precipitation is formed, the decrease of pH is not enough to inhibit the precipitation reaction. When BaC_2O_4 precipitation is generated, the precipitation reaction will be incomplete. In the case that the amount of S^{2-} in the original solution is so small, the formation rate of CuS precipitation is fast and the precipitation amount is obvious. To solve this contradictory problem, it was discussed from two aspects:

(1) The solution contains H_2S and HS, and their ionization rate is very fast, can be very fast ionization to produce S^{2-}, so in the solution of original S^{2-} and Cu^{2+} combined to form precipitation, S^{2-} occurs supplement, consumption, and replenishment (all are instantaneous). The reaction process of forming precipitation may be:

$Cu^{2+} + H_2S – CuS + 2\ H^+$, $Cu^{2+} + 2\ HS – CuS + H_2S$

(2) Before the experiment, the students can be divided into groups, and a group of 3 to 5 people is appropriate. The idea of the experiment is decided by the group, and the experiment is conducted by the group, to cultivate the students' independent hands-on ability and team negotiation consciousness. The layout of the experiment report is filled out by the students themselves, and the suggested template or prompt words can be given to guide the students to establish the framework structure of the experiment process and stimulate the students' consciousness and potential of systemization and structure.

2.2.4. "Double" summary

Students conduct both online and offline "double" summaries. (1) Online, students can use mind mapping, video and other ways to conduct personal course summaries by reviewing the "combination of science and practice" in the experiment process to make a summary, talk about their perception and harvest, this part can be implemented to individuals; (2) Offline, the inadequacies and gains in the experiment can be analyzed and summarized dialectically utilizing discussion or free debate among group members through the experiment in class.

2.2.5. Feedback survey

Students mastery can be assessed by setting questionnaires or test papers, and students' feedback can be collected through exploitative bullet screens or offline message boards, which is conducive to the improvement of follow-up experiments, "thinking" and then "advancing."

3. Online and offline mixed teaching under the background of digital age

3.1. Advantages of online teaching

If offline experimental teaching focuses on guiding students' hands-on ability, online experimental teaching helps cultivate students' thinking expansion ability. In many online cloud classes, students can acquire and master more knowledge and resources than in offline teaching, which is wider and more convenient. It also breaks the constraints of time and space and is more conducive to the teaching of epidemics, bad weather, bad environment and other emergencies.

3.2. Digital experimental teaching means

The single teaching with only online teaching is putting the cart before the horse. The combination of online

and offline teaching is more conducive to stimulating students' interest in learning. Because of the problems found in the teaching process of inorganic chemistry experiment courses in colleges and universities, such as inadequate pre-class preparation, vague learning objectives, and experimental mistakes, teachers should make full use of "cloud classroom" and combine it with traditional teaching mode to form a complementary teaching mode, which not only provides a platform and guarantee for students' independent learning but also steadily improves the teaching quality of inorganic chemistry experiment courses. Shorten the teaching time of topics, provide theoretical basis and implementation space for students' hands-on practice, and effectively solve the drawbacks in the teaching of inorganic chemistry experiment courses [6]. Encourage students to exert their subjective initiative, strengthen the spirit of ownership, and cultivate students' innovative thinking, comprehensive quality and interdisciplinary ability.

3.3. Digital experimental environment

As a chemistry laboratory, there is a pungent smell, and the environment is not as clean as other laboratories, because the usage rate is higher, and the laboratory management system is not as rigorous as other laboratories. The inflammable, explosive and corrosive chemicals in the laboratory make every part of the experimental environment have security risks. Being in this environment for a long time will cause potential threats to the physical and mental health of teachers and students. In terms of laboratory management, students can be given more autonomy, give full play to students' subjective initiative, professional advantages and their existing imagination, and appropriately change, arrange, design and manage the laboratory. This mode not only cultivates students' comprehensive qualities such as hands-on creation and management but also cultivates students' professional and technical abilities.

To create an excellent experimental environment, teachers should not only pay attention to the external environment and internal supply and demand but also have a good management system. Therefore, the construction of safe and green inorganic chemistry laboratories and scientific and efficient laboratory management is not only a necessary condition for improving the experimental teaching level but also a necessary guarantee for optimizing the teaching quality. The digital experimental environment enables researchers to meet this requirement.

4. A new path of putting theory into practice - "One teacher teaches many"

Traditional teaching usually has some problems, such as being inflexible and single, and the students are easy to follow the text and do not think about its deep meaning. Therefore, the diversity, timeliness and innovation of teaching methods have become the focus of educators. The "many" of the so-called "one teacher teaches many" is reflected in the diversified curriculum design, diverse teaching methods, and many aspects of teaching content. It aims to guide students to solve the problems of "how to preview," "how to self-study," "how to quickly and accurately locate the unknown points in the course" and so on, and perfectly interprets the truth that "teaching people to fish is better than teaching people to fish."

4.1. Dynamic teaching

On the one hand, knowledge is not immutable, but a process of dynamic development. At first, the theoretical knowledge we learn from books is inherent in our thinking, and with the progress of experiments, the experiments carried out may have the possibility of verifying the original theory, deepening the original theory or even overruling the original theory to form a new theory. Therefore, taking dynamic teaching as the entry point is expected to realize "one teacher teaches many." Dynamic teaching is often accompanied by the monitoring of online platforms, through the release of phased tasks such as in-class tests, chapter tests, perceptions and other real-time understanding and attention to students' mastery and learning dynamics.

On the other hand, students are in a developmental state. Chemistry as a practical course, to learn inorganic chemistry well, not only requires students to have a correct learning attitude but also needs students to have a correct learning method. Therefore, dynamic teaching is also a teaching method to help students develop better learning habits and improve student's ability to adapt to the environment.

4.2. The reference to ideological and political elements in the curriculum

The implementation of moral education improves the quality of talent training to comprehensively promote the construction of curriculum ideology and politics is a major goal of the current curriculum design. Among them, the education of professional courses in colleges and universities is the most important thing to train future successors. To achieve this fundamental task, it is necessary to put forward clear requirements for the teaching mode of professional courses. In the process of knowledge imparts and ability training, students can be helped to establish a correct worldview, life and moral values. Professional knowledge can be traced to the development process of disciplines, to adapt to the development of the era [7,8].

If the ideological and political elements of the curriculum are simply and roughly integrated into it, it can be said that it is even more difficult, and it may reduce students' interest in learning in the classroom. In the curriculum, as a teacher, it is difficult to implement one thing, to integrate the ideological and political elements into the curriculum. Modern inorganic chemistry has developed so far, as the basic course of materials, electronics, and other aspects of inorganic chemistry, condensed a large number of domestic and foreign chemists and ancestors of the effort and wisdom, Pauling, Mendeleev, Madame Curie and other to obtain the truth for decades of continuous experiments, hard work cases, to combine the corresponding theoretical knowledge points with the stories of many scientists and the Party's educational policy, political ideas and patriotic feelings perfectly integrated, to cultivate students' scientific rigorous attitude, social responsibility and sense of mission, to solve problems in a variety of ways, as well as innovative thinking and other ideological and political elements [9].

4.3. Teaching students according to their aptitude

In the individual aspect, it is important to reasonably examine the advantages and disadvantages of students, such as if the student's practical ability is very good, but the logical thinking ability is relatively weak, teachers can encourage and guide more. In addition, in other aspects, such as some groups or collectives, they can also be classified and then taught according to their aptitude. For students not majoring in chemistry or college of Chemistry, experimental courses can be reasonably arranged according to the different class hours, credit requirements and teaching standards of their majors or colleges [10].

Basic operation experiment and preparation experiments can be opened for all students, through a variety of experiments to improve students' ability, such as the preparation of potassium nitrate, aimed at training students to master the basic chemical operations such as weighing, dissolution, filtration, and so on, and then shape students' good experimental skills. Besides, relatively simple determination experiments can be set up such as the determination of dissociation degree and dissociation constant of acetic acid, to investigate and cultivate students' objective and rigorous scientific research spirit and attitude [11]. By understanding the working principle and correct use of common chemical instruments such as acid meter and spectrophotometer and other basic experiments, students can expand their knowledge of inorganic chemistry experiments and basic chemical literacy. Due to the accuracy and operation of the instrument may have a certain difference, then the measurement results may have a certain gap, to guide the students to carefully deal with the experimental data, analyze the experimental error, develop a scientific, pragmatic, rigorous experimental attitude and excellent style of study. For engineering and medical students, the preparation of ferrous ammonium sulfate and magnesium sulfate heptahydrate can be set up, to facilitate students to understand and master the laboratory preparation methods of these two industrial products, deepen the understanding of the relevant knowledge of the corresponding professional students, and help their correct use, to benefit the industry in which they are located.

For chemistry majors or chemistry college students, there are often unified teaching standards and class hours, and credit requirements, the school requires students to carry out the necessary experimental determination and basic experiment preparation process, add some experiments on the determination of elemental properties, independent design experiments and comprehensive

design experiments.

(1) Students in the specific operation of the elemental property experiment, by observing the change of color, precipitation, and gas generation, vividly understand the nature of various elements [12].

(2) For the independent design experiment and comprehensive design experiment, the comprehensive evaluation method and multiple teaching methods may be targeted and put forward higher requirements for the comprehensive application of students' knowledge and experimental skills.

(3) Students are not only required to accurately understand the experimental principle, but also to consult relevant materials and literature and obtain effective and usable knowledge, design reasonable experimental steps, carry out correct and standard experimental operations, solve various problems encountered in the experiment, and finally write a complete experimental report [9].

(4) For top-notch students who are interested in experiments and have strong hands-on ability, teachers can set up laboratories in different research directions, so that students can consult relevant literature, operate experiments, have a preliminary understanding of the current research status and relevant frontier knowledge, expand students' new knowledge, allow students to obtain relevant scientific research results in advance, and lay a solid foundation for future study and research.

5. Reflection and comprehensive evaluation of after-class teaching

5.1. Analyze the advantages and disadvantages of the course design process

Dialectically analyzing the advantages and disadvantages of the course design process should be considered in various aspects. For example, the goal of "integration of truth and reality," the scientific nature of "data processing" and "error analysis," the subjectivity of the dynamic change of "teachers" and "students," the flexibility of "teaching and learning" and "teaching methods," the integrity of "curriculum conception and evaluation," the development of "curriculum design keeps pace with the era," "students are the ones who develop," and so on. Dialectically and rationally viewing the course effect, analyzing the problems and improving the problems is an effective means to promote the benign development of the inorganic chemistry target course [13].

5.2. Stage assessment and comprehensive evaluation feedback results

The experimental teaching adopts the process evaluation method (percentage system): Independent learning 20%; Experimental operation 40%; Paper theory score 20%; Experiment report 10%; Experiment safety 5%; Extended studies 5%. Evaluate from both macro and micro aspects, focusing on the overall effect while trying to implement the individual.

6. Conclusion

6.1. The deficiency of the current experimental teaching of Inorganic Chemistry

6.1.1. The traditional concept of experimental education has the risk of "complacency"

Is the default mode of "experimental purpose - experimental principle - experimental process - experimental conclusion" of "always so" right? When it comes to the process of experimenting, most students and even teachers can't help but blurt out this model. However, through the actual investigation, it is not difficult to find that the starting point of this model is to let students "do experiments" and "do experiments well," whether students personally participate in drawing inferential examples is still to be discussed, and may restrict students' innovation ability [14].

6.1.2. The construction of the teacher team needs to be improved

Most of the new forces of education teachers, although they are rich in learning and reading poetry and books, have a very credible teaching ability, but most of the new teachers are a little lack of teaching experience, the teaching mode is quite "solidified" traces, easy to fall into the traditional frame book cycle, cannot simplify complicated knowledge, from simple to deep, students are not easy to understand. In the new force, there are also some outstanding, it can be old and new, flexible grasp of teaching trends [15], understanding the students' learning situation and knowing the changing, which is what is needed.

6.1.3. The lack of teaching effect evaluation

Teaching evaluation, often from the subjective feelings of teachers lacks systematic and statistical evaluation, although the combination of online and offline teaching of the class has a certain improvement in performance but only the individual class, obviously lacks persuasion. Therefore, the parallel class design with larger data sampling and more scientific analysis of the learning process and learning effect is an effective way to test the effect of the combination of online and offline teaching in the inorganic chemistry experiment course teaching.

6.2. Outlook

The development of science and technology depends on talent, and the cultivation of talent depends on education. The background of the digital era of big data provides us with new opportunities. Teachers should evaluate the situation, rationally plan and make use of existing resources, and seize good opportunities [10]. There may be the following solutions to optimize the course design:

(1) To strengthen the construction of college teacher teams, teaching and research activities can be actively carried out for new teachers, and inter-school and school-enterprise cooperation can be expanded.

(2) Realize the change of teaching concept. The original traditional teaching concept is changed to the new teaching concept under the background of big data, highlighting the main position of students, and aiming at amplifying students' subjective initiative and innovation enthusiasm.

(3) Greening the experiment. As an important part of practical teaching, inorganic chemistry experiments should implant environmental protection concepts such as protecting the environment and reducing pollution into the minds of students, so that they can put environmental protection concepts in the first place in experiments and even in daily life.

(4) Realize the "upgrading" of the inorganic chemistry experiment teaching method, combine the traditional teaching mode, take its essence and discard its dross. Realize the transformation from a single offline teaching to a combination of online and offline teaching, realize the dynamic transformation between online and offline teaching, and constantly upgrade the teaching method.

(5) Innovate teaching quality evaluation methods. The traditional evaluation methods generally focus on "in class," light "before class, after class" and other obvious deficiencies, so increasing the "pre-class preview" and "after class summary" link assessment proportion is the meaning of the problem. The comprehensive evaluation method of this paper can make up for the shortcomings of the traditional way.

(6) The proper use of the empowering tool of big data, reasonable design of inorganic chemistry experiment course process, let students be involved in it, implement the student-centered results-oriented education concept, which is conducive to the cultivation of students' independent learning ability, innovative thinking, environmental awareness, communication and coordination ability, teamwork and sharing accomplishment, etc.

Funding

Shandong Jiaotong University Undergraduate Teaching Reform Research Project, "Exploration and Practice of Ideological and Political Teaching of Engineering Chemistry under the mode of 'OBE Concept' and 'Trinity' integration" (Project No.: 2023YB07)

Disclosure statement

The authors declare no conflict of interest.

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