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The Development and Application of Observation Scale Based on Discipline *Core Competencies* in *Pre-Service Teacher Students* Simulation Teaching: Taking Chemistry as an Example

Master Thesis

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Declaration

The thesis entitled ″The Development and Application of Observation Scale Based on *Discipline Core Competencies* in *Pre-Service Teacher Students* Simulation Teaching: Taking Chemistry as an Example″ has been undertaken by me at the Faculty of Education, Palacký University Olomouc, under the supervision of Mgr. Peng Danping, Ph.D.

The author declares that the submitted thesis results from research under the supervisor's guidance. To the best of the author's knowledge, apart from the content that has been cited, this thesis does not contain any research results published or written by any other individual or group. The individuals and groups who have contributed to this research are acknowledged in the text.

Olomouc, 18 April 2024 Signature:

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Abstract

With China proposing its *Core Competencies* framework in 2016, the research on *Core Competencies* combined with disciplines has become a hot concern for many Chinese education researchers. *Core Competencies*, as a comprehensive ability oriented to the 21st century, it sets higher teacher and student requirements. The teacher education training of the whole system is receiving more and more attention from governments of various countries. As future teachers, *PST-Students* must reflect the cultivation and improvement of *Core Competencies* in their classrooms. Therefore, Existing research lacks a *PST-Students* simulated classroom observation scale to reflect *Core Competencies* and quantitatively analyze the actual classroom. While testing the implementation of *Core Competencies* by *PST -Students*, various problems in the classroom are found, which allows teachers to understand their teaching better, is conducive to improving the quality of education, and promotes the comprehensive and harmonious development of students' *Chemistry Core Competencies*.

Firstly, this research is based on the primary theoretical basis of classroom observation and *Core Competencies*, combine with the characteristics of the chemistry discipline; while analyzing the classroom structure, the *Chemistry Core Competencies* are integrated into the evaluation system, and the classroom observation scale is compiled. The author chose the Prof. Cui’s *LICC-Paradigm*, more suitable for localized research in China, as the guiding example of this research. Then, the author makes a deep analysis and interpretation of the content of the *Core Competencies* of the chemistry discipline, and according to the principles and basis of the compilation of the observation scale, the *LICC-Paradigm* and *Chemistry Core Competencies* are integrated, and the classroom observation scale was initially formed. Secondly, the author uses the expert review method to conduct a validity test on the scale and uses Cronbach's Alpha Coefficient, ICC, and Kendall's W coefficient to conduct a reliability test, proving that the scale has good reliability and validity. After the construction is completed, it has been modified by experts many times, and finally formed a chemistry *PST-Students* simulated classroom observation scale with 4 dimensions, 19 perspectives, and 42 observation points. Finally, the author applies the constructed classroom observation scale to the actual classroom and uses methods of triangulation to prove that the scale builds in this research meets the principles of operability and comprehensiveness and has specific practical value.

The chemistry *PST-Students* simulated classroom observation scale constructs in this research is a preliminary attempt in this field, hope to provide some references for pre-service chemistry teacher education and training and provide a reliable tool for observing the simulated teaching of chemistry *PST-Students*.

Keywords: Classroom Observation Method, *Core Competencies*, *Discipline Core Competencies in Chemistry*，*LICC-Paradigm*

Chapter1. Introduction

Since January 2015, the curriculum plan and discipline curriculum standards for general high schools in People's Republic of China (hereinafter referred to as China) have begun systematic revision. This marks a new stage in the reform of basic education curriculum in China: creating a curriculum system for the information age. At the same time, the new concept of *Core Competencies* has entered the research field of many Chinese subject education researchers.

1.1. Rationale for the Study

Research on *Core Competencies* and *Discipline Core Competencies in Chemistry* (hereinafter referred to as *Chemistry Core Competencies*) is still emerging in China. Under the *Chemistry Core Competencies* background, teaching is expected to enable students to master the necessary knowledge of chemistry and improve students' comprehensive quality. Only by conducting a deep and thorough analysis of teaching activities can theoretical research be carried out better. Traditional classroom teaching evaluation methods are single and highly disciplinary; existing research needs to be targeted more, and the discipline characteristics need to be stronger. The universal observation scale cannot highlight the characteristics of the chemistry discipline and the characteristics of *Pre-Service Teacher Students (hereinafter referred to as PST-Students)*. Therefore, a logically clear and reasonable classroom observation scale must be developed.

There are many types of quantitative classroom observations. Considering the strong regional and cultural characteristics of the classroom and the perspective of sample acquisition, the author chose a classroom observation Paradigm with Chinese localization characteristics. The "LICC Classroom Observation Paradigm" (hereinafter referred to as *LICC-Paradigm*), released by Cui Yunhuo (2010), refers to the four elements of classroom teaching: Learning, Instruction, Curriculum, and Culture. The quantitative indicators are designed with three levels of observation points, four dimensions, 20 perspectives, and 68 observation points (more details will be discussed in Chapter 2).

This research is based on the three major theories of classroom observation, *Core Competencies,* and *Chemistry Core Competencies*, combined with the *LICC-Paradigm* as a research model and created a *PST-Students* simulated classroom observation scale that conforms to the actual teaching of Chinese *PST-Students*.

1.2. Statement of the Question

Since the existence of human society, education has existed. The term "education" originates from the Latin words Educare, meaning "to bring up," and Educere, meaning "to bring forth."(Hoad,1993; Vico & Marsh, 1999). There are many classifications of education. The most common division is between formal, non-formal, and informal education. (La Belle,1982) Some theorists distinguish the three types based on the learning location: formal education occurs in school. Formal education happens in a complex institutional framework. (Eshach, 2007)

As the basic unit of school education, the classroom is where education honestly and frequently occurs. Its importance and significance are unquestionable, and a deep analysis and exploration of classroom teaching is naturally the premise and foundation of all research. Prof. Manabu Sato (2000) once clearly stated that the center of school reform is in the classroom. Regardless of the type of classroom research, teachers and students have always been the focus of classroom observation research. Due to their special status, it is worth noting that *PST-Students* have both the identities of teachers and students in the classroom. They are transitioning from receivers of knowledge to transmitters of knowledge, from focusing on theoretical knowledge to concentrating on practical knowledge. In pre-service development, most of the classroom practice of *PST-Students* belongs to simulated classroom. It is a reduced, artificially controllable simulated teaching environment exclusively for *PST-Students*. (Allen & Clark, 1967) *PST-Students* carry out teaching skills training here, which can help them integrate theory and actual classroom situations to achieve unity of knowledge and action.

As a comprehensive quality facing the 21st century, *Core Competencies* not only put higher demands on the *PST-Students* group. More importantly, it tests their understanding of its connotation and can integrate knowledge into the classroom and pass it on to middle school students in combination with actual conditions. As the most essential part of the professional ability development of future teachers, evaluating the practical knowledge of *PST-Students* is critical and needs to be more three-dimensional.

Therefore, based on the rapid changes in the era, the identity of *PST-Students*, and the particularity of simulated teaching, combining specific disciplines to judge the understanding level of *PST-Students* on *Core Competencies* and their output level in the teaching process is crucial for the construction of the teacher development system, the improvement of classroom evaluation research, and the guarantee of education quality.

1.3. Purpose of the Study

The Ministry of Education of China has stipulated in the "Outline of Basic Education Curriculum Reform" (2001) that teaching evaluations should promote students' comprehensive development, improve teachers' quality, and improve teaching practices. This indicates that China's teaching evaluation methods are undergoing fundamental changes, and the traditional teaching evaluations that lack evidence or have a single proof can no longer meet the requirements of the new era. With the release of *Core Competencies* and *Discipline Core Competencies*, evaluating the presentation level of *Core Competencies* and *Discipline Core Competencies* in actual classrooms has also become the focus of teaching evaluations.

As the most common and important form of teaching practice for *PST-Students*, simulated teaching is widely used in various scenarios (such as micro-teaching, educational internships, teaching skills competitions, teacher qualification interviews, etc.). However, in the existing classroom observation research, the classroom observation scales constructed for *PST-Students* could be more affluent, and there needs to be more objective and scientific evaluation tools. Moreover, research that can meet the discipline characteristics of the chemistry discipline is even rarer.

The author is trying to construct an observation scale that can scientifically, reasonably, and effectively evaluate the mastery and application level of *Chemistry Core Competencies PST-Students* and its presentation in simulated teaching. It will also be applied in practice to explore the current evaluation mechanism of *PST-Students* in detail. The ultimate goal is to promote education through evaluation.

1.4. Research Problem

To perform the research, the following questions were posed:

1. How to evaluate the mastery level of *Chemistry Core Competencies PST-Students*?
2. How to evaluate the application level of *Chemistry Core Competencies PST-Students*?
3. How to evaluate the simulated teaching level of chemistry *PST-Students*?

1.5. Significance of the Study

This research aims to construct a simulated classroom observation scale for chemistry *PST-Students*. It is a research result based on the dynamics of essential education reform in the new era of China. It is also meant to better evaluate the overall quality and ability of chemistry *PST-Students* in the face of the 21st century.

Firstly, there are relatively few studies (Wang, 2019; He, 2000; Li, 2021) on the classroom observation scale with the characteristics of *Core Competencies* combined with the chemistry discipline at this stage. This research enriches the research practice related to chemistry classroom observation.

Secondly, the *LICC-Paradigm* has strong specificity and practicality and has also adapted well to various disciplines in the development stage. However, its original design intends to evaluate front-line middle school teachers better. Due to the difference in observation objects and observation environment, *PST-Students* have entirely different characteristics from front-line middle school teachers. It is mainly reflected in the dual identity and the ideal simulated teaching environment. This research is a new attempt to apply the *LICC-Paradigm* in the field of *PST-Students*.

Thirdly, with the continuous development of teacher education and training, more and more middle school teachers realize the importance of teaching evaluation. They began to participate actively in this professional teacher activity. However, *PST-Students* are still in the pre-service development stage and must have corresponding awareness and ability. This research also hopes to add more specific evaluation tools for front-line teaching evaluation, which can provide evidence-based help and guidance for teacher evaluation, student mutual evaluation, etc.

Chapter2. Literature Review

This chapter describes four critical theories and their related information: classroom observation, *Core Competencies, Chemistry Core Competencies,* and simulated classroom.

2.1. Classroom Observation

2.1.1. Definition of Classroom Observation

Observing the behavior of personal peers is something research starts doing in infancy. It is a natural activity in individual lives, work, home, and social situations. Observation refers to understanding things through the coordinated action of multiple senses, such as vision, hearing, and touch. It is a purposeful, planned, and relatively persistent perceptual activity. When observation is applied to the classroom environment, it is called classroom observation. Jackson (1968) reports a study that found primary school teachers engage in up to 1000 interpersonal exchanges daily. In another study by Adams and Biddle (1970) on videotapes, there was a change in ″activity″ every 5-18 seconds, and in each class, the speaker and listener changed an average of 174 times. The classroom is a relatively private place. The classroom is a complex and busy concrete manifestation of this. This environment includes teachers, students, and possibly other administrators and spectators. Observing from different perspectives, research will get utterly different observation activities.

> If lessons are worth observing then they are also worth analysing properly, for little purpose is served if, after a lesson, observers simply exude goodwill, mumble vaguely or appear to be uncertain why they are there, or what they should talk about. (Wragg, 1999, p.3)

Observation from the student's perspective refers to the student's observation of knowledge, such as observing chemical reaction phenomena, understanding chemical reaction laws, and identifying chemical substances. Observation from the teacher's perspective refers to how teachers obtain feedback and improve teaching effectiveness through observing students. From the standpoint of administrators, observation refers to observing and supervising teachers and students to ensure teaching quality and improve teaching efficiency. Observation from the perspective of bystanders refers to random visits to classrooms by parents on open days or observational research on classrooms by educational researchers, etc.

In addition to this, there are many other ways of classification. For example, British Hopkins (1993) classified it into open, focused, structured, and systematic observations according to the scope of observation situations and the degree of systematization of observation. His classification is more detailed, reflecting the subtle differences of various classroom observations, and is more targeted when applied. Usually, it is impossible to use one type of observation alone in research, but multiple types of observation are combined to achieve complementary advantages.

The classroom observation referred to in this article is the observation of the entire classroom by bystanders at the school. The discipline of observation is the bystander, and the object of observation is the classroom as a whole, including students, teachers, the teaching process, etc. This kind of observation is both a means of research and evaluation. It is a professional activity to record, analyze, and study the classroom operation through observation, seek the improvement of students' classroom learning, and promote teacher development based on this.

2.1.2. Classroom Observation Methods

Observation has always been an essential means of scientific research. As early as ancient Greece, Aristotle believed that scientific research was based on observing facts, using induction to rise to general principles, and then returning to observation through deductive reasoning. Whether in natural science research or social science research, observation is recognized as an indispensable method. Modern sociologist Max Weber also pointed out that all social research begins with observation and ends with long-term individual observation. Researchers can obtain many materials through this observation to clarify their views and thoughts. (Finch & Shils, 1949)

Since the advent of classroom teaching, the behavior of observing the classroom has always existed. Influenced by the quantification, systematization, and structuring of other disciplines, starting in the 1950s, the observation method of quantitative tools began to be widely used in educational research. 1950 American social psychologist R.F.Bales proposed the "interaction process analysis" theory. He developed 12 categories of interpersonal interaction behavior coding as the research framework for classroom observation and thus began the systematic classroom observation quantitative research. This is the first time the observation method has been applied in education. In 1960, American classroom research expert N.A.Flanders (1970) researched the "interaction classification system" and developed a set of coding systems for recording the language interaction situation in the classroom.

The emergence of quantitative tools makes the implementation of classroom observation more operable. Researchers record and interpret classroom events according to the pre-designed scale content, and the implementation is relatively easy. However, relying solely on quantitative tools to study the classroom has its one-sidedness. It cannot record non-verbal discipline feelings, so it inevitably misses a lot of important classroom information. In the 1970s, qualitative research methods such as ethnography were introduced into classroom observation. Since then, researchers can describe and interpret classroom events in words based on their own experiences. In recent years, people have been exploring and pursuing the integration of qualitative research and quantitative research. Two different research orientations enrich classroom observation from various levels and other directions. The combination and complementation of the two orientations have become the mainstream trend of classroom observation development. For example, researchers (Good & Brophy, 1974) proposed the observation; description; reflection; understanding method of combining qualitative and quantitative classroom observation, helping observers to avoid biased behavior in the classroom and their works With "class examples" as the material, a unique "perspective classroom method" was formed.

The development of classroom observation in China started relatively late. In the 20th century, there was no term for ″classroom observation″ in China. (Chen 2000) People generally used "Class Listening" (Class listening is a kind of professional development activity for teachers. Specifically, it refers to teachers or educational researchers going deep into the classroom to observe the teaching behavior of other teachers. Attending classes can help teachers learn from their peers and colleagues, promote teaching and research, and promote self-reflection to further improve teaching ability.) to replace classroom observation. (Cui, 2012) At that time, listening to classes had no strict organizational form or standardized standards. It was generally new teachers listening to the courses of old teachers to familiarize themselves with the key points of teaching and teaching methods. Schools occasionally organize mutual class listening activities among old teachers to improve the teaching level of teachers. However, there is no unified evaluation standard during the class listening process, and the class listening between teachers is relatively casual, each expressing their own opinions.

In the 1980s, Chen Xiaoda (1988) first pointed out that domestic class listening is not standardized, lacks unified evaluation standards, and its results lack reference value and cannot effectively improve the current situation of classroom teaching. In the 1990s, Wu Kangning (Cheng, 1994; Cheng, 1995; Wu, 1995) and others proposed through research that classroom observation can be carried out from several aspects, such as classroom questioning, teaching requirements, evaluation guidance, and cooperation, and specific records are made through the classroom observation registration form. Gu Lingyuan (1997a, 1997b, 1999) in Shanghai started to study classroom observation technology. She believed that classroom observation was indispensable if China's education wanted to progress at that time. So, he observed over a hundred classroom teachings and then analyzed and classified classroom teaching in Shanghai. Summarized the shortcomings and deficiencies of classroom teaching, and finally formed a systematic analysis method. In 2000, Chen Yao conducted a complete discussion on classroom observation in her master's thesis, "Research on Classroom Observation Methods." At the beginning of the 21st century, Chen Yao (2002) wrote *Classroom Observation Guide*, the first book in China that thoroughly explains classroom observation. The book defines classroom observation with confirmed cases, explains the reasons and benefits of classroom observation, and, for the first time, combines qualitative and quantitative research to study classroom observation, which is highly practical.

On May 8, 2007, the *China Education News* reported on the related research of "Yuhang High School in Hangzhou on Classroom Observation." (Cui, 2010) Since then, a batch of research content on the *LICC-Paradigm* has appeared in China, and research results have been published in authoritative education magazines in China. With the continuous attention of Chinese scholars to classroom observation research, hundreds of papers are published in relevant journals every year.

Figure 2.1 Number of Classroom Observation Articles Published in China, 2007-2023 (Searched on CNKI)

Note. China National Knowledge Infrastructure (CNKI) is China's largest academic information platform and academic search platform. (The same below)

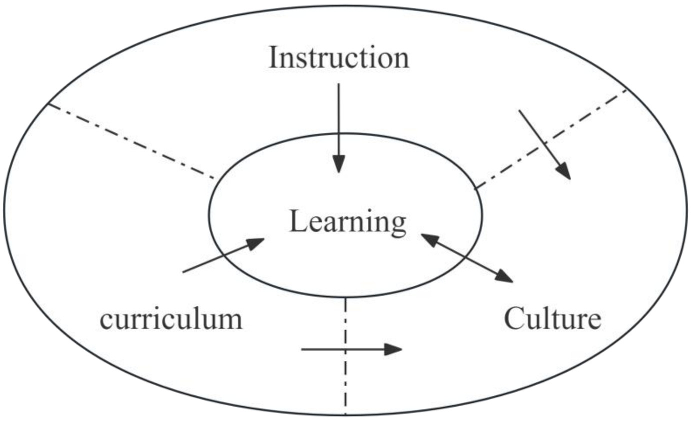
2.1.3. *LICC-Paradigm*

Chinese schools have mandatory regulations for teachers' class listening tasks every semester. Depending on the different situations of different schools, it is generally between 10-20 sessions. (Cui, 2012) In November 2005, Prof. Cui Yunhuo from East China Normal University begins a cooperative exploration with Yuhang High School in Hangzhou. After many field visits, surveys, and research, he obtained valuable firsthand data. He believes there are many problems in class listening in China, and the most core and prominent problems are reflected explicitly in three aspects. (Cui, 2012)

(1) The first is no cooperation. Due to the existence of compulsory class listening tasks, teachers need to complete them to cope with inspections. Moreover, the general attitude of most teachers towards this is "refuse to cooperate, superficial cooperation and independent completion et al." This kind of class listening must have the spirit of cooperation to complete this complex teaching task, and it cannot reflect the professionalism of teachers. (2) The second is no evidence. Class listening often requires a lot of records and post-class evaluations. Because there are only regulations for class listening tasks and a lack of requirements for class evaluation, some teachers often do not want or do not participate. Even if they participate in class evaluation, they usually have many loopholes. Mainly reflected in its opinions are too random; most teachers' class evaluations are wherever they think or stop when they point and taste the taste. (3) The third is that the views are too disciplineive and personalized, and the expression is often: what kind of personal empiricism would the author teach if the author were to teach? The third is that the opinions could be grander and more abstract, such as needing more students to observe; it would be better if students could participate more, etc. These behaviors cannot be called professional teacher activity; the participants often have little effect.

After more than two years of research, the *LICC-Paradigm* was officially released. This Paradigm structures the classroom into four elements: learning, instruction, curriculum, and culture. Prof. Cui believes that the starting point and end point of classroom observation are all aimed at improving student classroom learning. So, among the four elements, student learning is at the core.

Diagram 2.1 Schematic Representation of The 4 Elements of The *LICC-Paradigm*



(Shen Yi et al., 2007)

According to the logic of observation and research, each dimension is decomposed into five perspectives, and each perspective has 3 to 5 observation points, eventually forming an observation framework of 4 dimensions, 20 perspectives, and 68 observation points. It also stipulates the procedural framework of pre-class meetings, in-class observations, and post-class meetings. This ultimately forms a complete research paradigm.

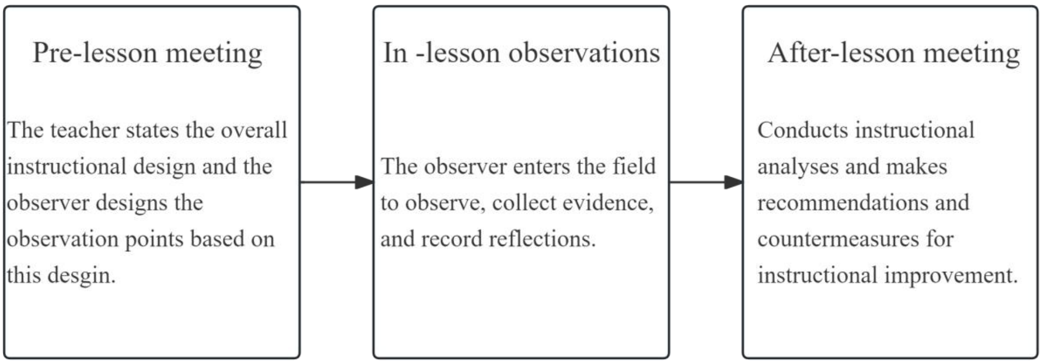
Table 2.1 A research Framework for The *LICC-Paradigm*

Observation Dimension	Observation Perspective	Observation Opinions (Provide an example)
Learning	Preparation Listen Interact Independence **Achieve**	There are three observation opinions in the "Achieve" perspective: 1. Are students clear about the learning objectives of the lesson? 2. What is the evidence of achievement of the pre-determined goal (ideas; assignments; expressions; demonstrations; boards)? How many were reached? 3. What objectives were generated by the lesson? What was the effect?
Teaching	**Section** Presentation Dialogue Guidance Wit	There are three observation opinions in the "Section" perspective: 1. What are the components of a classroom? Is it organized around instructional objectives? 2. Are the sessions geared toward all students? 3. How is the time allocated for the different segments; behaviors; content?
Curriculum	Objective **Content** Implementation	there are four observation opinions in the "Content" perspective: 1. How was the textbook handled (add; delete; combine; create; replace)? Is it reasonable?

	Evaluation	2. What was generated in the classroom? How is it handled?
	Resources	3. Are the subject's characteristics, ideas, core skills, and logical relationships highlighted? 4. Is the capacity appropriate for the class? How to meet the needs of different students?
Culture	Reflection	There are three observation opinions in the "Democracy" perspective:
	Democracy	1. What does classroom discourse (quantity; timing; objects; wording; interjections) look like?
	Innovation	
	Care	2. What about the number and duration of student participation in classroom activities? What is the classroom climate like?
	Characteristic	3. What is the teacher-student behavior (situational settings; call and answer opportunities; seating arrangements) like? How was the relationship between students?

(Shen Yi, et al., 2008)

Diagram 2.2 The Usage Process of The *LICC-Paradigm*



The book *Classroom Observation: Towards Professional Lesson Evaluation* written by Shen Yi et al. in 2008, comprehensively presents the specific application of the *LICC-Paradigm* in disciplines. The book shows the formation process of the Paradigm and its particular practice in disciplines such as biology and chemistry. After nearly 20 years of exploration, the *LICC-Paradigm* has been recognized by many Chinese education researchers and front-line middle school teachers. Classroom observation research based on the *LICC-Paradigm* has also been practiced and applied in more disciplinary fields.

Figure 2.2 Number of *LICC-Paradigm* Articles Published in China, 2010-2023 (Searched on CNKI)

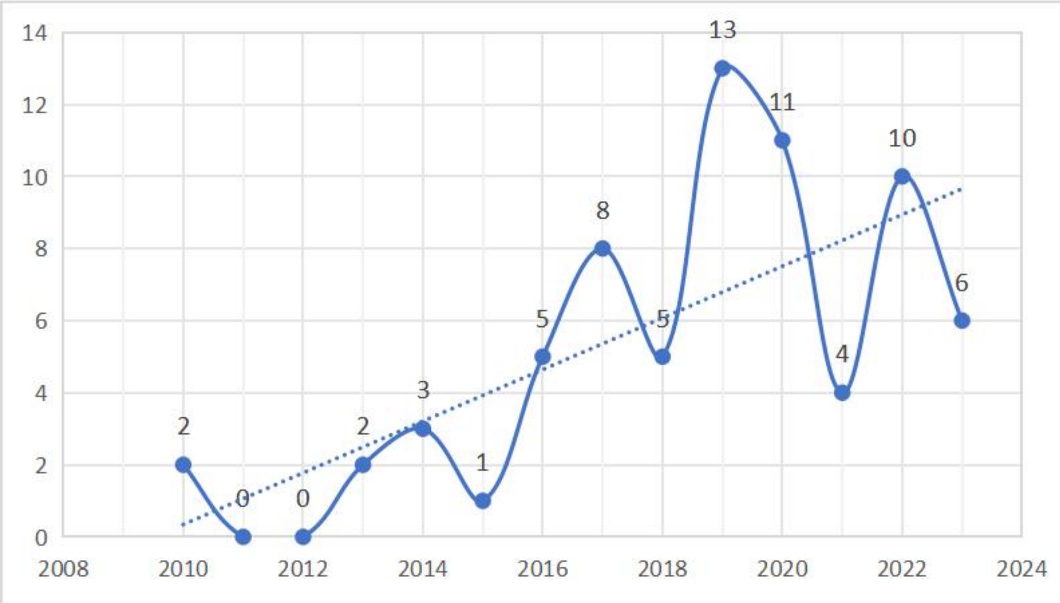
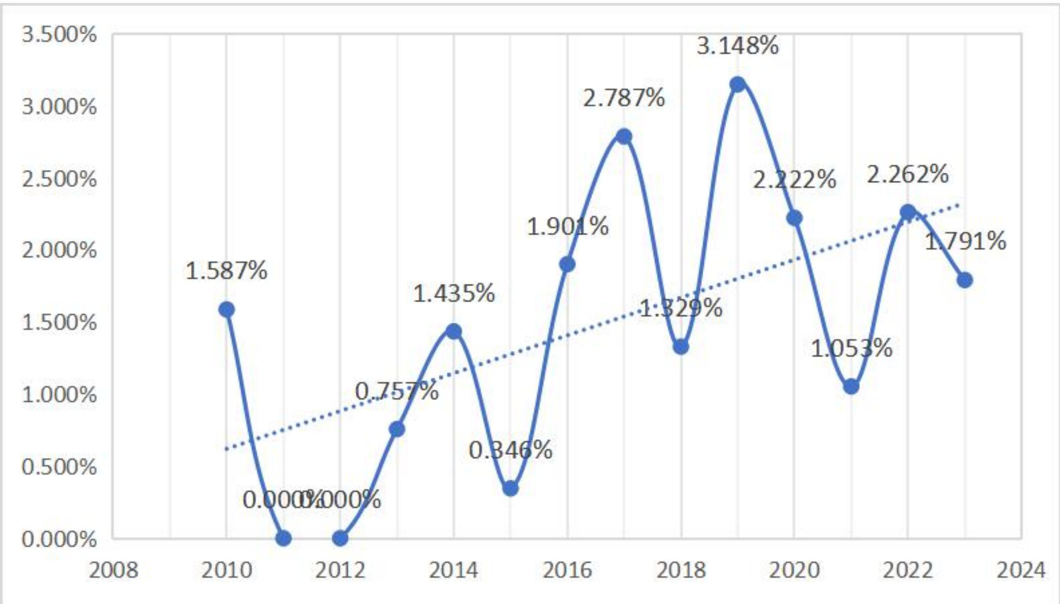


Figure 2.3 *LICC-Paradigm* VS. Classroom Observation, Number of Articles Published in China, 2010-2023 (Searched on CNKI)



2.2. *Core Competencies*

After humanity entered the 21st century, the rapid and unexpected development and widespread use of Information and Communication Technology quickly ushered society into the information age. The outstanding psychologist and education reformer

J. Bruner (1977) said, "Knowledge is a process, not a product." The 21st Century themes include global awareness, financial, economic, business, entrepreneurial, civic, health, and environmental Competencies. All these themes are interdisciplinary topics derived from the context of the 21st century, aimed at helping students solve complex personal, social, economic, professional, and global problems. (P21, 2007)

The term "Competencies" in the dictionary is competence or competency, and its Latin root is complete. (Gordon et al., 2009, p.39) From the perspective of etymology, it refers to the aggregation of various abilities or powers to appropriately respond to situations. (Trueit, 2012, p.67) Among them, com- means together, and peter means to pursue, strive forward. Taken together, compete means to strive together. This clearly shows the original meaning of people striving together to adapt to the environment. (Lu Gusun Ed., 1989, as cited in Zhang, 2016)

2.2.1. Relevant Research in The Economic Cooperation and Development Organization

The Economic Cooperation and Development Organization (hereinafter referred to as OECD), under the leadership of the Swiss Federal Statistical Office (hereinafter referred to as SFSO) and with the substantial assistance of the National Center for Education Statistics (hereinafter referred to as NCES) of the U.S. Department of Education, launched the Core Competency Framework project at the end of 1997. This project *Definition and Selection of Competences: Theoretical and Conceptual Foundations* (hereinafter referred to as DeSeCo plan), aimed to provide a theoretical basis and evaluation framework for the *Programme for International Student Assessment* (hereinafter referred to as PISA) launched by OECD countries in the same year and also served as another international evaluation plan for adult competencies, the ″Adult Competencies and Life Skills Survey″ (hereinafter referred to as ALL). (Salganik et al., 1999)

The DeSeCo plan published its final report *Core Competencies for Successful Life and Healthy Society (Lin, 2004)*, marking the completion of the OECD Core Competency Framework. The project lasted for six years, gathering many experts and stakeholders from various fields such as sociology, evaluation, philosophy, anthropology, psychology, economics, history, statistics, education, policy-making, policy analysis, unions, employers, domestic and international institutions, and mobilized professional forces from at least 12 countries, undergoing years of theoretical and practical testing.

To adapt to the rapid and continuous changes in technology, the increasing diversity of society, and the new forms of interdependence created by globalization, the OECD established the concept of *Competency*. However, it realized that "In social sciences, there is no single use of the concept of competency, nor is there a widely accepted definition and uniform theory." (Rychen & Salganik, 2000)

Therefore, when defining competency, the OECD adopted a practical concept orientation, trying to make the definition as clear, rational, and scientifically acceptable as possible. Accordingly, the OECD succinctly defined "competency" as follows: Competency is not just knowledge and skills. It is the ability to meet complex needs in specific situations by using and mobilizing psycho-social resources (including skills and attitudes). (OECD, 2005)

The types of competencies needed to adapt to different situations are numerous and inexhaustible. The strategy adopted by DeSeCo plan is, for practical purposes, to select and establish the most fundamental and critical competencies, known as "key competencies." Each critical competency must meet three conditions (OECD, 2005):

（1）Produce valuable results for society and individuals.

（2）Help individuals meet essential needs in diverse situations.

（3）It is crucial not only to discipline matter experts but also to everyone.

This reflects *Core Competencies*' three characteristics: value, transferability, and democracy. Accordingly, the OECD established three categories of *Core Competencies* (OECD, 2005):

（1）The ability to interactively use tools, specifically including the ability to use language, symbols, and text interactively; the ability to use knowledge and information interactively; the ability to use technology interactively;

（2）The ability to effectively interact in heterogeneous groups, specifically including the ability to establish good relationships with others, the ability to cooperate, the ability to manage and resolve conflicts;

（3）The ability to act autonomously, including the ability to adapt to grand situations; the ability to form and execute life plans and personal projects; the ability to maintain rights, interests, scope, and needs.

The internal logic of the three categories of *Core Competencies* is the relationship between people and tools, people and society, and people and self. (OECD, 2005)The three categories of *Core Competencies* are neither separated from each other nor mechanically combined. On the contrary, they are organically connected, interact, integrate, and are a dynamic structure; constellation that constantly changes to adapt to the needs of different situations.

2.2.2. Relevant Research in The European Union

To address the challenges of globalization, the knowledge economy, and the information age, the European Council prioritizes providing ″new basic skills.″ It emphasizes lifelong learning, ″extending learning from pre-school to retirement.″ (Gordon et al., 2009) In March 2001, the European Union (from now on referred to as EU) Council approved the establishment of the *Education and Training 2010 Work Program*, intending to establish a new European education and training system suitable for the needs of the knowledge society by 2010, with the core being the formation of the European Core Competency Framework. On December 18, 2006, the European Parliament and the European Council jointly approved this framework, named *Recommendation on Key Competences for Lifelong Learning*, which became the programmatic document for the EU and its member states to establish education in the information age. This framework draws on the achievements of DeSeCo plan and fully reflects European education's characteristics and development needs. Its purpose is to develop the *Core Competencies* necessary for the European knowledge society as future educational goals and to provide support for EU member states to achieve core competency goals. The EU defines competency as the integration of knowledge, skills, and attitudes applicable to specific context. Context mainly refers to personal, social, and professional situations. (Gordon et al., 2009)

At the same time, the EU defines *Core Competencies* as follows: *Core Competencies* are the competency that all individuals need to achieve self-realization and development, become active citizens, integrate into society, and succeed in employment. (Gordon et al., 2009) This defines core competency from a specific functional perspective. So, what are the *Core Competencies* that all individuals need? The EU lists eight *Core Competencies*:

> (1) Communication in the mother tongue; (2) Communication in foreign languages; (3) Mathematical competence and basic competences in science and technology; (4) Digital Competencies; (5) Learning to learn; (6) Social and civic competencies; (7) Sense of initiative and entrepreneurship; (8) Cultural awareness and expression. (Gordon et al., 2009, p10)

For each core competency, the EU first gives a precise definition and then makes clear explanations from the three aspects of necessary knowledge, skills, and attitudes. these eight competencies are equally important because each will contribute to a successful life in the knowledge society. Among them, many competencies overlap and interweave with each other. Since these competency names are result-oriented and connected with specific disciplines and life, they do not explicitly state people's mental processes and abilities. Therefore, the framers of the *European Reference Framework* made the following remarkable statement. (Gordon et al., 2009) Several themes apply to the entire Reference Framework: critical thinking, creativity, initiative, problem-solving, risk assessment, decision-making, and constructive management of emotions, all play a role in the eight *Core Competencies*. This means that the above-listed mental processes and abilities act as an ″underlying thread″ running through and permeating the eight *Core Competencies*.

2.2.3. Relevant research in the United States

In the early 1990s, in response to economic changes and the trend of internet development, the United States (hereinafter referred to as the US) Secretary of Labor established a high-end expert working committee in 1991. The committee has two main tasks: identifying the work skills need in the 21st century and assessing whether American schools are teaching these skills. The committee published a research report titled *What Work Requires of Schools*, pointing out that Although schools are honestly and consciously striving to adapt to new needs, due to the lack of clear and consistent guidance, schools are continuing the educational system and methodology designed nearly a hundred years ago, which meets the needs of corporate organizations that are vastly different from today. (the US Department of Labor, 1991) This posed a severe challenge to the educational system, content, and methods of the industrial age. In 2002, the U.S. Department of Education and influential private companies and civil research institutions such as Apple, Cisco, Dell, Microsoft, and the National Education Association established the *Partnership for 21st Century Skills* (hereinafter referred to as the P21), they begin to develop the *21st Century Skills* systematically needed to adapt to the information age and knowledge economy, and the grand *21st Century Skills* Movement is launched.

After several years of effort, the *21st Century Learning Framework* and the corresponding curriculum and research report systems are launched. The P21 has entered its second decade, and more and more schools, districts, and states in the United States are adopting and implementing this framework. It has become an essential theoretical and practical basis for leading the United States and the world to build a curriculum system for the information age and knowledge society. In the P21, *21st Century Skills* is equivalent to *Core Competencies* in the OECD and EU frameworks. The P21 defines *21st Century Skills* as follows: *21st Century literates* go far beyond basic reading, writing, and arithmetic skills. It refers to how to apply knowledge and skills to modern life situations. (P21, 2002)From this point of view, *21st Century Skills* has two fundamental connotations:

(1) It is a high-level skill or literacy, and its corresponding category is basic skills, although it never denies the latter;

(2) It is situation-related, it is the product of knowledge and skills applied to 21st -century life and work situations.

Based on this understanding, the P21 has developed a detailed *21st Century Learning Framework*. This framework comprises *Key Disciplines and 21st Century Themes* and *21st Century Skills*. (P21, 2009) The former focuses on knowledge, the latter focuses on skills, and the two are interdependent and intertwined. Learning, information, and life skills only make sense when connected with core discipline knowledge. Conversely, core discipline knowledge can only be deeply understood when it is obtained through *21st Century Skills*. (P21, 2007)

In this framework, *Key Disciplines* include English, reading or language arts, world languages, art, mathematics, economics, science, geography, history, government, and civics. It is worth noting that economics has become one of the *Key Disciplines*. The Partnership believes that 21st century education must be built on a solid foundation of content knowledge. However, here, content knowledge does not mean storing a bunch of facts but refers to discipline concepts and ways of thinking; its purpose is to let students think like discipline experts. (P21, 2007)

Therefore, 21st century themes require the connection between discipline knowledge and real-life situations and the internal connection between different discipline knowledge. It aims to cultivate students' interdisciplinary awareness and the ability to use multidisciplinary knowledge to solve complex problems. *21st Century Skills* includes three interconnected categories (P21, 2002):

（1）Learning and innovation skills, including creativity and innovation, critical thinking and problem-solving, and communication and collaboration.

（2）Information, media, and technology skills, including information literacy, media literacy, and information and communication technology literacy.

（3）Life and career skills, including flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, and leadership and responsibility

2.2.4. Relevant Research in China

Since 2010, China has realized the importance of skills for the 21st century. In 2012, the 18th National Congress of the Communist Party of China (hereinafter referred to as the CPC) and the Third Plenary Session of the 18th Central Committee of the CPC in 2013 put forward the requirement of moral education, which was implemented in practice. In 2014, the Ministry of Education formulated and issued the

Opinions on Deepening Curriculum Reform and Implementing the Fundamental Task of Fostering Integrity and Promoting Rounded Development of People , proposing that the Ministry of Education will organize research to propose a *Core Competencies* system for students at all stages, clarifying the necessary character and key abilities that students should possess to adapt to lifelong development and social development needs. Since then, a joint research group of nearly a thousand researchers from hundreds of research institutions led by Beijing Normal University has been officially established. After three years of research, China's student development *Core Competencies* results were released on September 13, 2016.

Article 5 of T*he Education Law of The China* (2021) stipulates the educational policy as Education must serve socialist modernization and the people, must be combined with productive labor and social practice, and cultivate all-round developers of morality, intelligence, physique, beauty, and labor for socialist construction and successors. *Core Competencies* are concertizing China's educational policy, connecting macro educational concepts, training objectives, and specific educational teaching practices with scientific, contemporary, and national characteristics.

Student development *Core Competencies* mainly refer to the necessary character and critical abilities students should possess, which can adapt to lifelong and social development needs. The fundamental starting point for developing China's student development *Core Competencies* is to concretize and refine the party's educational policy, implement the fundamental task of moral education, cultivate all-round people, and enhance the core competitiveness of national talents in the 21st century. China's student development *Core Competencies*, with the cultivation of *Rounded Development of People* as the core, are divided into three aspects: cultural foundation, self-development, and social participation, and are comprehensively manifested as 6 significant elements (*Core Competencies* Study Group, 2016):

(1) Humanistic background,

(2) Scientific spirit,

(3) Learning to learn,

(4) Healthy living,

(5) Responsibility,

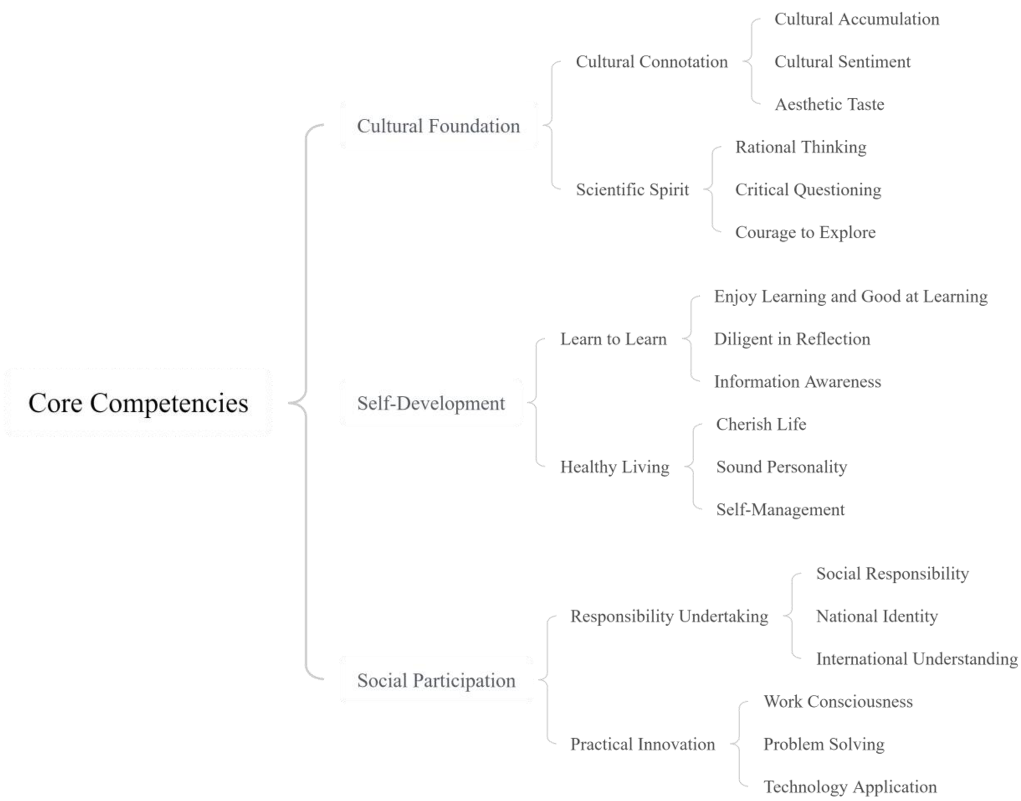
(6) Practice and innovation

It is refined explicitly into 18 essential points, such as national recognition. Each Competency is interconnected and complementary, promotes the other, and plays a role in different situations. For the convenience of practical application, the six significant literacies are further refined into 18 essential points, and their main performances are described. Based on this framework, specific performance requirements for students at each stage can be further proposed according to student age characteristics.

Diagram 2.3 Schematic Diagram of The Elements of Chinese *Core Competencies*

(*Core Competencies* Study Group, 2016)

Diagram 2.4 Chinese *Core Competencies* Content Framework



(*Core Competencies* Study Group, 2016)

The connotation of the cultural foundation is that culture is the root and soul of human existence. The emphasis on the cultural foundation is to acquire knowledge and skills in various fields such as humanities and science, to master and apply the excellent wisdom of humankind, to cultivate the inner spirit, to pursue the unity of truth, goodness, and beauty, and to develop into a person with a broad cultural foundation and higher spiritual pursuits.

The connotation of self-development is that autonomy is the fundamental attribute of a person as a discipline. Self-development emphasizes the ability to effectively manage one's learning and life, to recognize and discover self-worth, to tap into one's potential, to effectively cope with complex and changing environments, to achieve a colorful life, and to develop into a person with a clear life direction and quality of life.

The connotation of social participation is that sociality is the essential attribute of a person. Social participation emphasizes the ability to handle the relationship between self and society well, to cultivate the moral norm and behavioral norm that modern citizens must abide by and fulfill, to enhance social responsibility, to improve the innovative spirit and practical ability, to promote the realization of personal value, to promote social development and progress, and to develop into a person with ideals and beliefs who dares to take responsibility. (Lin, 2016)

2.3. Discipline *Core Competencies* in Chemistry

To further deepen educational reform and comprehensively promote quality education, the Ministry of Education of the China issued *The General High School Curriculum Plan and Standard Experimental Draft* in 2003. After more than ten years of rapid development, the original guiding documents could no longer meet the new requirements of the new era for improving the quality of all citizens and the quality of talent training. To better adapt to the needs of the times, develop the unique educational value of quality education, and establish the intrinsic connection between *Core Competencies* and discipline, the Ministry of Education launched the revision of the general high school curriculum in 2013. In January 2018, after more than three years of hard work by the revision expert group, *The General High School Chemistry Curriculum Standard* (2017 Edition) was published based on the wisdom and strength of all sectors of society. After a series of curriculum experiments, teaching pilots, and educational research, *The General High School Chemistry Curriculum Standard*

(2017 Edition 2020 Revision) was published in 2021, marking the official completion of a new round of high school chemistry curriculum standard reform in China.

The document begins by describing chemistry:

> Chemistry is an essential discipline that studies the composition, structure, properties, transformation, and application of matter at the atomic and molecular levels. Its characteristic is to understand matter from a microscopic level, describe matter in symbolic form, and create matter at different levels. (Ministry of Education of China, 2020, p1)

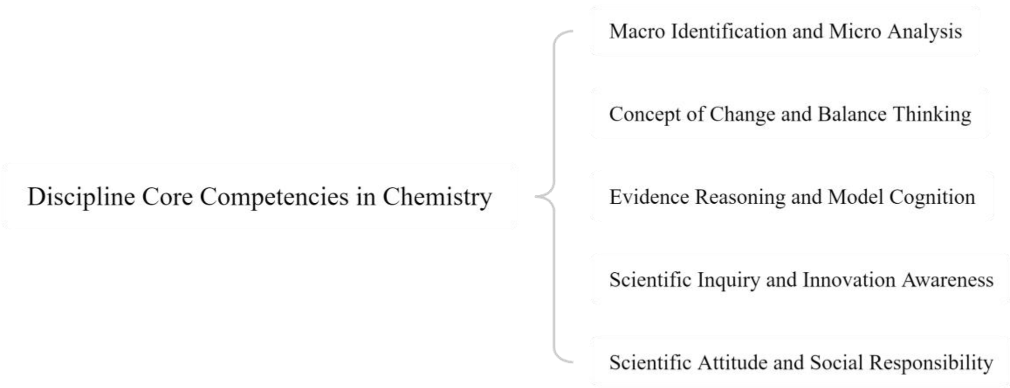
It also explains the curriculum standard and the *Core Competencies* of the chemistry discipline:

> The general high school chemistry course is an introductory education course connected with compulsory chemistry or science courses. Implementing moral education, developing quality education, promoting the scientific spirit, and improving students' *Core Competencies* are essential. The *Chemistry Core Competencies* are the scientific Competencies that students must possess and are an indispensable foundation for lifelong learning and development. The chemistry course is irreplaceable in inheriting scientific culture and cultivating high-quality talents. (Ministry of Education of China, 2020, p1)

Diagram 2.5 Schematic Diagram of Student Competencies Development Process

The *Chemistry Core Competencies* include 5 aspects: "Macro Identification and Micro Analysis, Concept of Change and Balance Thought, Evidence Reasoning and Model Cognition, Scientific Inquiry and Innovation Awareness, and Scientific Attitude and Social Responsibility". (Ministry of Education of China, 2021) These five aspects are based on the chemistry learning process of high school students, each with its emphasis, and they complement each other. "Macro Identification and Micro Analysis, Concept of Change and Balance Thought, and Evidence Reasoning and Model Cognition" require students to form the thoughts and methods of the chemistry discipline; ″Scientific Inquiry and Innovation Awareness″ encourages students to be innovative from a practical perspective; "Scientific Attitude and Social Responsibility" further reveals the higher-level value pursuit of chemistry learning.

Diagram 2.6 Schematic Diagram of The Structure of *Chemistry Core Competencies*



The most significant difference between this curriculum standard and the 2003 version is that it evaluates the achievement of students' *Chemistry Core Competencies* at different learning stages according to the chemistry academic quality standards, actively advocates the integration of "teaching, learning, and evaluation," and enables each student's *Core Competencies* in chemistry to develop to varying degrees. (For a detailed interpretation, see Chapter 3)

2.4. Simulated Classroom

2.4.1. Characteristics of a Simulated Classroom

A simulation is an imitative representation of a process or system that could exist in the real world. (Banks, 2001) It can be applied to many disciplines, such as education, economics, sociology, political science, management, medicine, etc. A simulated classroom generally refers to a form of teaching in a specific environment within a short period, where teachers demonstrate various teaching skills and organizational forms through spoken and body language. Teacher is a particular profession, often metaphorically referred to as the engineer of the human soul. teaching cannot just be theoretical; teachers face individual lives, bear the great mission of cultivating the future of humanity, and shoulder the responsibility of transmitting the crystallization of human wisdom. The simulated classroom is a low-cost, efficient, and fast way to test a teacher's teaching ability. Its primary purpose is to identify teachers' essential qualities and skills, which are often used in teaching training, interviews, and other scenarios. The differences between it and the regular classroom mainly focus on the following four points:

(1) Different display objects. The object of simulated teaching is generally teaching research experts, school leaders, and peers. They are tasked with observing its teaching behavior and evaluating and judging after the course. In regular classroom study, students and teachers have a particular psychological advantage conducive to their performance.

(2) Different display purposes. Simulated teaching is more like a teaching show; it requires you to try your best to show your excellent and beautiful side, strives to achieve perfect teaching links and achieve perfect teaching effects. Regular teaching aims to achieve teaching goals; its starting and end points are students. It does not blindly pursue effects but cares more about the development of students.

(3) Different display content. Due to time and venue constraints, simulated teaching can often only display a knowledge point that tends to be theoretical and conceptual, and its content is usually carefully designed by teachers. It is a self-directed performance with idealized teaching links and classroom feedback. The content of regular teaching is generally under the overall arrangement of the entire school year preparation group, based on the teaching tasks formulated by the curriculum standards and other programmatic documents. It has clear teaching goals and plans and is a long-term, systematic, and scientific teaching activity.

(4) Different display organization forms. Simulated teaching has strong randomness and uncertainty. Teachers and observers are often relatively unfamiliar states; even if there is planning, they need to adjust at any time according to the situation on the spot, which tests the teacher's ability to adapt to randomness. Regular teaching faces students; a long-term grinding teaching foundation exists under normal circumstances. Teachers' understanding and mastery of students will increase, and they can better judge their thinking patterns and teaching feedback.

2.4.2. Micro-gramme Teaching

Micro-teaching was invented by Dwight W. Allen at Stanford University in 1963 and was later used to train various educators. This method is one of the most influential innovations in teacher education in the early 1960s and 1970s. A review of the evidence for micro-teaching, undertaken by John Hattie as part of his Visible Learning project, found it was the 6th most effective method for improving student outcomes. (Hattie, 2012) *As future teachers, PST-Students* are the primary users of simulated teaching at this pre-professional stage. The people found from the Teacher-

Training programs of several normal universities in China that micro-teaching is the primary training form for *PST-Students*' simulated classrooms.

One of the founders of micro-teaching, American education Doc. Dwight W. Allen (1963), believes: Micro-teaching is a reduced, artificially controllable simulated teaching environment, which can help pre-service teachers and in-service teachers specifically train a certain teaching skill. Through literature reading and research, the author defines it from the essence of micro-teaching as using rapidly developing media technology based on modern education theory, according to the principles of teaching evaluation and feedback, systematically training teacher skills, it decomposes the complex and highly integrated classroom, trains them one by one and then combines them, provides a controllable, reduced teaching environment, and turns the complex and multi-factor restricted teaching ability training into a controllable, operational teaching ability training method. Its usual form is for students to prepare a short course (usually 10-15 minutes), played by classmates as the educated, and accompanied by teacher or classmate evaluation after the course ends. The content includes lesson speaking, lesson plans, course implementation, teaching interaction, etc.

Many studies (Dehejia & Wahba, 1999; Amobi, 2005) have confirmed that micro-teaching positively impacts *PST-Students*' skill training, including but not limited to the teaching goals being relatively straightforward and singular, teaching feedback and reflection being timely and comprehensive, role changes being diversified, and cooperation being positive and effective. At the same time, some researchers (Huang, 2012; Tian 2015; Liu, 2018) have pointed out that micro-teaching has many drawbacks. the most typical is that peers play the role of the educated; their understanding and acceptance of knowledge is somewhat different from real students; it is an "almost perfect student." This false situation may make *PST-Students*' teaching lose its authenticity, and it is easy to become more idealized in involvement and implementation to deviate from the actual teaching of middle school.

Chapter3. Development of Classroom Observation Scale Based on Discipline *Core Competencies* in Chemistry

This study's chemistry classroom observation scale is based on the *LICC-Paradigm* combined with *Chemistry Core Competencies*. It has been improved for the particular group of *PST-Students*. Due to the different settings of educators and educatees in micro-teaching from regular classrooms, the first-level observation dimensions of student learning and teacher teaching have become *PST-Students* Learning and *PST-Students* Teaching. The second-level observation perspective generally follows the content of *LICC-Paradigm*, but some individual perspectives have been added or reduced. The specific observation content in the third-level observation points is combined with the requirements of different *Core Competencies* levels in the new curriculum, the identity characteristics of *PST-Students*, and the form characteristics of simulated teaching, which is the most significant difference from Prof. Cui. Different levels of *Core Competencies* need to be evaluated and scored at various observation points. The correspondence between observation points and multiple levels is shown in the third section of this chapter.

3.1. Principles of Observation Scale Development

One of the critical steps in designing an observation scale is to choose appropriate observation points, so research needs to select observation points based on the characteristics of the specific observation content. When observing a class, researchers need to feel the class as a whole and analyze the class in detail, achieving a combination of macro and micro perspectives. However, every class is ever-changing, so research needs the help of a detailed classroom observation scale. Observers should follow the following principles when compiling the scale (He, 2022):

Principle of Scientificity: the scale compilation cannot be arbitrary; it needs to be guided by scientific theory and methods and constructed with scientific thinking. The observation system that is built must objectively conform to the laws of classroom teaching. The selection of observation points must have a scientific basis and can genuinely explain the research topic, providing feasible improvement strategies for the classroom.

Principle of Selectivity: the classroom is a complex system of multiple determined elements, uncertain events, and behaviors. Observers cannot record every behavior and situation in the school during classroom observation. Therefore, when compiling the observation scale, research needs to determine the observation points according to observability, recordability, and interpretability requirements, discard useless information for research in time, and transform some abstract and general implicit observation points into observable and evaluable indicators.

Principle of Operability: the classroom observation scale designed in this study is applied to classroom observation. Users include educational researchers and teachers at different stages of development. Therefore, the observation table must be operable and applicable, the scale structure must be simplified, and the description of the observation point must be easy to understand. It is convenient for observers to understand and use.

Principle of Diagnosability: Observers observe and evaluate according to the scale indicators and specific observation points and analyze the presentation level of *PST-Students* in specific chemistry classroom simulation teaching. At the same time, it can also diagnose the areas that need to be improved in classroom teaching, propose specific modification opinions, and improve the level of classroom teaching.

Principle of Development: the goal of classroom observation evaluation is to improve the teaching level of *PST-Students* and develop the comprehensive quality of *PST-Students*, not simply for comparison and supervision. Therefore, research must implement the principle of development when observing and evaluating. Promote mutual learning and expected growth among *PST-Students*.

3.2. Steps and Rationale for the Development of the Observation Scale

The "Classroom Observation Scale Based on *Chemistry Core Competencies*" compilation process includes three stages: analysis and design, modification and reconstruction, and practical application. Following this procedure ensures the scientificity and feasibility of the designed observation scale. Here are the specific introductions to these three stages.

Firstly, the analysis and design stage. The design of each indicator in the scale cannot be arbitrarily fabricated; it should follow a scientific template and conform to the actual situation of *PST-Students*. Therefore, after reading much-related literature, the author determined the topic of this research through discussions with tutors and expert scholars in the field of chemistry education. This research is based on the *Chemistry Core Competencies* and constructs a scale according to the *LICC-Paradigm*. The *LICC-Paradigm* has undergone many observation tests in the chemistry teaching and research group and the biology teaching and research group of Yuhang High School in Hangzhou at the initial design stage, so its practicality in the chemistry discipline is guaranteed. Although the *LICC-Paradigm* has fixed dimensions and observation points, researchers can appropriately modify it by combining it with the *Chemistry Core Competencies*. After the analysis, research was conducted according to the first-level observation dimension in the *LICC-Paradigm*. This deconstructs the classroom into four primary aspects. Then, divide the second-level observation perspective according to the *LICC-Paradigm*. Finally, according to the actual teaching, the observation perspective is refined into several observation points, and the observation scale system is preliminarily formulated in a step-by-step refinement.

Secondly, the modification and reconstruction stage. The birth of a scientific scale is not a once-and-for-all process; it must be repeatedly modified and gradually improved. After the preliminary design of the scale was completed, the author conducted the first round of expert opinion consultation with experts. Some secondary observation perspectives were added or deleted, and the order of some tertiary observation points was adjusted. Then, the second round of expert opinion consultation was conducted. The author communicated with expert scholars for multiple rounds, and after receiving feedback opinions, he made various modifications to these questions and reconstructed the observation scale.

After completion:

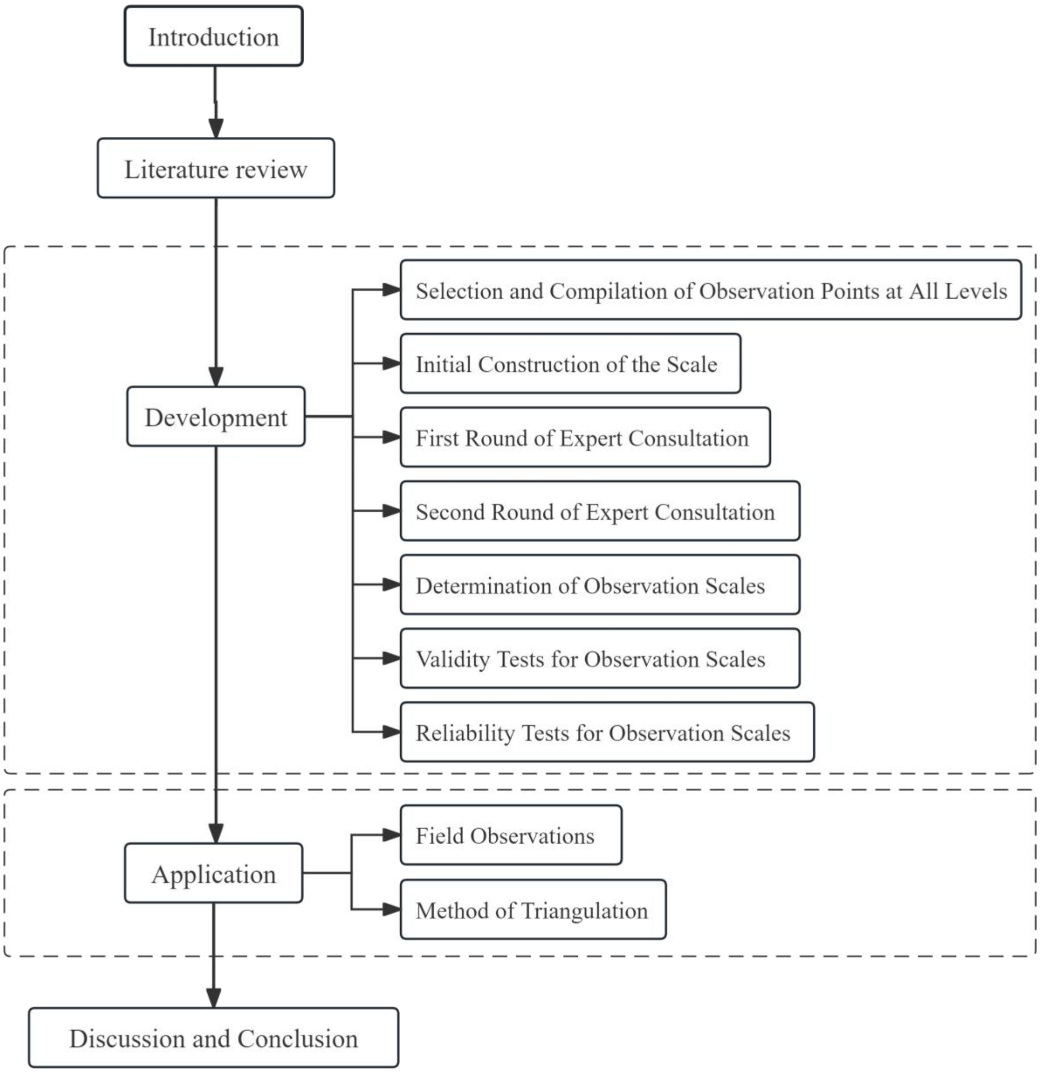
(1) Invite front-line high school chemistry teachers and related university teachers to conduct expert reviews to test the scale's validity.

(2) Try to practice in the micro-grid classroom of *PST-Students* and collect data to test the scale's reliability after practice.

(3) Combine the opinions and suggestions in practice, revise the scale again, and finally form the scale.

Finally, the practical application stage. After multiple modifications, the scale has a certain degree of scientificity and can be officially used. The author cooperates with Prof. Chen Jiping of Yunnan Normal University to conduct a triangulation test. The author uses the observation scale constructed in this research, and Prof. Chen Jiping uses the evaluation method in his curriculum plan.

Diagram 3.1 Schematic Diagram of The Process of Observation Scale Compilation



3.3. Construction of the Observation Scale

This part elaborates on the observation indicators at all levels in the scale, explaining the basis for establishing the observation dimensions. The classroom observation theory is used as a guide throughout establishing the first-level observation dimension, the second-level observation perspective, and the third-level observation point. The classroom observation theory runs through the entire process of formulating the scale.

3.3.1. First-level Observation Dimension

Because this scale is based on the *LICC-Paradigm*, the observation dimensions still follow the classifications in the Paradigm. The first-level observation dimensions in the *LICC-Paradigm* are student learning, teacher teaching, classroom nature, and curriculum culture. Since there are no real students in the simulated classroom, and the *PST-Students* have both the teacher and student identities, the observation object is only the *PST-Students*. Therefore, the author has readjusted the first two items of the first-level observation dimension to *PST-Students learning and PST-Students Teaching, and the last two items remain unchanged, as are* classroom nature and classroom culture. Afterward, the classroom is further subdivided into these four significant aspects.

3.3.2. Second-level Observation Perspectives

PST-Students **Learning Dimension:** As *PST-Students* are still learning, their understanding of chemistry and their perception of the teaching profession may need to be more mature. School education ensures they meet the relevant standards and correctly comprehend knowledge, skills, professional attitudes, and ethics. Research primarily focuses on their essential competencies when observing *PST-Students* in their "student" role. Therefore, the observation perspectives for this dimension include preparation, competence, and cognition.

PST-Students **Teaching Dimension:** Teachers are the classroom organizers, responsible for managing classroom order, organizing teaching activities, and imparting knowledge to students. Therefore, a teacher's teaching ability directly impacts the effectiveness of instruction. The observation perspectives for this dimension include segments, presentation, dialogue, guidance, and adaptability.

Curriculum Dimension: the nature of the curriculum is closely related to the content taught, and the teaching content also correlates with teaching outcomes. The observation perspectives for this dimension include objectives, content, implementation, assessment, and resources.

Culture Dimension: Classroom culture reflects the teacher's style and gives observers a genuine sense of the classroom environment. Although research lacks real students in this simulated setting, research can still consider aspects such as reflection, innovation, and distinctive features in research observation of classroom culture.

3.3.3. Third-level Observation Points

In the LICC Classroom Observation Scale, the general directions of the primary observation dimensions and the secondary observation perspectives are comprehensive and have been repeatedly validated as a scientific classification method. Therefore, this study only made modifications in response to the absence of the student role. However, the specific observation points at the tertiary level need to be adjusted according to the actual discipline matter. Therefore, after integrating *Core Competencies* and *Chemistry Core Competencies* and reading a large amount of related literature, the author has initially established the following observation points (Level Division of Discipline Core Competencies in Chemistry, see Appendix A; The Level of Academic Quality in Chemistry, see Appendix B.):

3.3.3.1. *PST-Students* Learning Dimension

Preparation: Regardless of the teaching experience, preparation before teaching is crucial for all teachers, as the preparation level directly determines the teaching quality. *PST-Students* are still in the learning stage, and their level of preparation represents the importance they attach to the activity of education, reflecting their essential attributes. Therefore, research must observe whether the *PST-Students*' teaching design matches their lesson plan presentation. Is the theoretical basis of the *PST-Students*' lesson plan presentation objective and accurate?

Competencies: Education is a gradual process, and accumulating experience and skills requires much practice. At the beginning of their learning, *PST-Students* need to solidify their foundation and strive to achieve the essential qualities a teacher should have. Therefore, research must observe: Are *PST-Students*' verbal representations up to requirements? Are *PST-Students*' nonverbal representations up to requirements? Does the *PST-Students*' grooming meet the requirements?

Cognition: Chemistry is the core force that reveals the mystery of life from elements. *Chemistry Core Competencies* is an essential scientific Competency for students and a foundation for lifelong learning and development. The chemistry course plays an irreplaceable role in the inheritance of scientific culture and in cultivating high-quality talents. The *PST-Students*' understanding of the chemistry discipline and its related knowledge directly determines the lower limit of the student's understanding of chemistry. Therefore, research must observe How well the *PST-Students* grasp the chemistry curriculum standards. How well do *PST-Students* grasp chemistry textbooks' content and organization logic? What is the *PST-Students*' level of chemical scientific and chemical teaching thinking?

Among them, the content and arrangement of the chemistry textbook, the chemical scientific thinking, etc., are all established based on the five *Chemistry Core Competencies* and the academic quality level in the new curriculum standards.

3.3.3.2. *PST-Students* Teaching Dimension

Section: the design of the teacher's teaching section plays a decisive role in teaching. A good teaching design allows students to understand. The teaching goal is like the brain, which is the ultimate purpose of the design. Therefore, research should observe: Does the content of each section of the teaching design serve the teaching objectives? Are the teaching or experimental sections conducive to student understanding?

Presentation: How teachers present knowledge will also affect students' understanding of knowledge. The presentation is not the more complex and advanced, the better, but it should be concise and clear. First, research must ensure students can clearly and accurately accept the information. The higher pursuit is secondary. Therefore, research should observe: Are the lesson plan presentation and the explanation process clear and accurate? Are the blackboard writing, multimedia, etc., presentations complete and correct? Is the experimental content part standardized and safe?

Dialogue: In the classroom, communication between teachers and students includes many forms, such as questioning, group discussion, questionnaires, etc. These forms of communication facilitate teachers to understand students' learning status. Therefore, teachers must recognize the role of dialogue. However, they also need to pay attention to the form and frequency of dialogue and refrain from engaging in dialogue for the sake of dialogue. Moreover, research needs to ensure the fairness of the dialogue and try to take care of every student, so research needs to observe: Are there enough exchanges between teachers and students in the lesson? Could teachers communicate with the majority of students? Is there value in communication in teaching design?

This observation perspective mainly reflects the importance of teaching feedback. Teachers need to understand students fully and may need to understand students' thoughts through dialogue and communication with students while taking into account all students and providing targeted suggestions for each interactive student.

Guidance: Because each student's acceptance status differs, one-on-one teacher guidance is essential. However, the teacher can only care for some students because the classroom teaching time is limited. Hence, the teacher needs to be good at observing which students have questions or operation errors. When guiding, you also need to pay attention to the method. Rough and impatient guidance may discourage students and make them lose interest in chemistry. Therefore, research must observe: Does the teacher give appropriate guidance while teaching? Is the teacher's guidance on student experimental part patient and meticulous?

Wit: An excellent teacher must have high teaching wit because the classroom situation is ever-changing and unpredictable. Although the observed scenario is simulated teaching, there is more than one *PST-Students* in the environment. How the *PST-Students* handle emergencies becomes particularly important when faced with emergencies. A suitable handling method can stabilize the classroom order and provide an excellent example for students. So, research must observe how the *PST-Students* handle unexpected situations. How well do the *PST-Students* grasp the overall course rhythm?

3.3.3.3. Curriculum Dimension

Objective: the teaching objective is the guiding mark of a lesson. If the aim is too high, it does not conform to the students' reality and cannot achieve good learning results. If the objective is higher, it will make students relax their attention to learning and cannot effectively utilize classroom efficiency. Therefore, research must observe: Are teaching objectives' design justified? Are the selection of teaching key points and difficulties of the course justified?

Content: the teaching content is the focus of a lesson. Whether the content setting is reasonable directly determines the success or failure of a lesson. Therefore, research must observe: Does the content in this lesson meet the required scenario? Is the content organized by the cognitive patterns of students in the *"Academic Quality Levels"*? Does the teaching design take care to relate to real-life situations and practical problems?

Implementation: the teaching implementation process is the focus of research observation. No matter how good the teaching design is, it is just empty talk and useless if it cannot be implemented well. The smoothness of teaching implementation has much to do with the teacher's level. Therefore, research must observe: Is the teaching process consistent with the lesson plan presentation and achieving the expected effect? Are activities appropriate and conducive to stimulating students' interest in learning? Is the logic of teaching knowledge points conducive to students' transfer and application?

Evaluation: the teacher's evaluation of students is critical. Teachers must encourage students to speak actively through evaluation to get better teaching feedback. Therefore, research must observe: Is the teacher evaluating students timely and motivating? Does the teacher's evaluation promote the implementation of teaching objectives?

Resources: According to the curriculum standards, teachers must strive to develop chemical teaching resources. At the same time, according to the requirements of green chemistry in Level 4 of ″Scientific Attitude and Social Responsibility*,″ research needs* to save the drugs used in the experiment. Therefore, research needs to observe: Does the experimental part embody the values of green chemistry? Does the teacher make full use of various teaching resources?

3.3.3.4. Culture Dimension

Reflection: The learning discipline should be the students, so whether the teacher's teaching methods can stimulate students' active thinking is crucial. The people should abandon the traditional one-way teaching style and respect the students' central position. Therefore, the focus of observation lies in: Does the guidance in the teaching design help students develop disciplinary thinking in chemistry? Does the guidance process contribute to students' problems and scientific consciousness?

Democracy: the classroom atmosphere can influence students' learning state. A democratic and equal atmosphere is conducive to developing students' creative thinking. Students are the prominent participants in the classroom. Therefore, research must observe: Does the teaching design adhere to the principle of student-centeredness? Are the communications between teachers and students equal and harmonious?

Innovation: Teachers need to update their teaching designs regularly, but more importantly, they should inspire students' innovative spirit. In the core competency of chemistry, ″scientific inquiry and innovation consciousness,″ students are expected to propose their new experimental ideas. Therefore, research must observe the following: What innovative points are in the teaching design? Does the teaching process help students generate new questions?

Care: Excellent teachers may view students as friends, genuinely caring for and nurturing them, earning their trust and affection. This greatly enhances students' enthusiasm for chemistry. Therefore, research needs to observe: Could the teacher pay attention to different situations in the classroom? Is the classroom atmosphere relaxed and lively?

Characteristic: Each lesson is unique, and every teacher has their strengths. Therefore, researchers should observe the classroom with an appreciative eye. The focus lies in the following: Does the simulated teaching have highlights? Do the *PST-Students* demonstrate any highlights throughout the process?

Inquiry: Inquiry-based learning is an active learning process where students explore questions independently during science classes. This aligns with the expectations of ″scientific inquiry and innovation consciousness″ and ″scientific attitude and social responsibility.″ therefore, research must observe: Does the teacher guide students in independent inquiry? Is the guidance process conducive to enhancing their innovation consciousness?

3.3.4. Initial Construction of the Scale

The preliminary constructed scale is shown in Table 3.1.

Table 3.1 The first Version of The Observation Scale

Topic				
Name		Time of lesson plan presentation		Average Score
Time		Whether the lesson plan presentation takes place before or after the course ends.		
Observation Dimension	Observation Perspective	Observation Opinions	Score (1-5)	Score (1-5)
Pre-Service Teacher Students Learning	Preparation	1. Does the *Pre-Service Teacher Students*' teaching design match their lesson plan presentation?		
		2. Is the theoretical basis of the *Pre-Service Teacher Students*' lesson plan presentation objective and accurate?		
	Competency	3. Are *Pre-Service Teacher Students*' verbal representations up to requirements?		
		4. Are *Pre-Service Teacher Students*' nonverbal representations up to requirements?		
		5. Does the *Pre-Service Teacher Students*' grooming meet the requirements?		
	Cognition	6. How well do the *Pre-Service Teacher Students* grasp the chemistry curriculum standards?		
		7. How well do *Pre-Service Teacher Students* grasp chemistry textbooks' content and organization logic?		
		8. What is the *Pre-Service Teacher Students*' level of chemical scientific and chemical teaching thinking?		
Pre-Service Teacher Students Teaching	Section	9. Does the content of each section of the teaching design serve the teaching objectives?		
		10. Are the teaching or experimental sections conducive to student understanding?		

	Presentation	11. Are the lesson plan presentation and the explanation process clear and accurate?		
		12. Are the blackboard writing, multimedia, etc., presentations complete and accurate?		
		13. Is the experimental content part standardized and safe?		
	Dialogue	14. Are there enough exchanges between teachers and students in the lesson?		
		15. Could teachers communicate with the majority of students?		
		16. Is there value in communication in teaching design?		
	Guidance	17. Does the teacher give appropriate guidance while teaching?		
		18. Is the teacher's guidance on student experimental part patient and meticulous?		
	Wit	19. How do the *Pre-Service Teacher Students* handle the unexpected situation?		
		20. How well do the *Pre-Service Teacher Students* grasp the overall course rhythm?		
Curriculum	Objective	21. Are the design of teaching objectives justified?		
		22. Are the selection of teaching key points and difficulties of the course justified?		
	Content	23. Does this lesson's content meet the required scenario?		
		24. Is the content organized by the cognitive patterns of students in the ″Academic Quality Levels″?		
		25. Does the teaching design take care to relate to real-life situations and practical problems?		
	Implementation	26. Is the teaching process consistent with the lesson plan presentation and achieving the expected effect?		
		27. Are activities appropriate and conducive to stimulating students' interest in learning?		
		28. Is the logic of teaching knowledge points conducive to students' transfer and application?		
	Evaluation	29. Is the teacher evaluating students timely and motivating?		
		30. Does the teacher's evaluation promote the implementation of teaching objectives?		
	Resources	31. Does the experimental part embody the values of green chemistry?		
		32. Does the teacher make full use of various teaching resources?		
Culture	Reflection	33. Does the guidance in the teaching design help students develop disciplinary thinking in chemistry?		

		34. Does the guidance process contribute to students' problems and scientific consciousness?		
	Democracy	35. Does the teaching design adhere to the principle of student-centeredness?		
		36. Are the communications between teachers and students equal and harmonious?		
	Innovation	37. What innovative points are in the teaching design?		
		38. Does the teaching process help students generate new questions?		
	Care	39. Could the teacher pay attention to different situations in the classroom?		
		40. Is the classroom atmosphere relaxed and lively?		
	Characteristic	41. Does the entire simulated teaching have highlights?		
		42. Do the *Pre-Service Teacher Students* demonstrate any highlights throughout the process?		
	Inquiry	43. Does the teacher guide students in independent inquiry?		
		44. Is the guidance process conducive to enhancing their innovation consciousness?		
Total Score				

3.4. Reconstruction and Determination of Observation Scales

The scale was revised using the opinion consultation method to make the observation scale more scientific, practical, and operational.

3.4.1. Views and Modifications Based on the First Round of Expert Consultation

After consulting with mentors and several experts in chemistry education online and offline, the author received revision suggestions after several rounds of communication. The author then independently used the scale to observe the national Teacher-Training competition videos, corroborated with the results given by the expert judges, and made adjustments in conjunction with the comments. The specifics are as follows:

The " Competency " observation perspective has been adjusted to "norm." the observation scale in this study is based on the two major theories of *Core Competencies* and "*Core Competencies* in Chemistry." the term "Competencies" is both repetitive and an overly broad expression, which is not precise enough. The primary purpose of this observation perspective is to observe the essential teaching quality of *PST-Students*, including their verbal and non-verbal behavior, all of which have mandatory regulations. The term "norm" is more precise and concise.

The perspective of "care" and the following observation points 39 and 40 have been deleted. Care is an essential ability and quality to become a teacher. However, in the context of simulated teaching, there are no real students, only teachers or classmates. In the face of them, it is difficult for *PST-Students* to care from an objective point of view genuinely. Even if care is performed in the interaction or dialogue of teaching design, it will appear very false. For these reasons, this observation perspective is directly deleted.

The order between observation points 3, 4, and 5 under the "norm" perspective, between observation points 14 and 15 under the "dialogue" perspective, and between observation points 31 and 32 under the "resources" perspective has been adjusted. Changing the order is to better conform to the logic of thinking and the order of observation to record better.

The revised scale can be seen in Table 3.2.

Table 3.2 The Second Version of The Observation Scale

Topic				
Name		Time of lesson plan presentation		Average Score
Time		Whether the lesson plan presentation takes place before or after the course ends.		
Observation Dimension	Observation Perspective	Observation Opinions	Score (1-5)	Score (1-5)
Pre-Service Teacher Students Learning	Preparation	1. Does the *Pre-Service Teacher Students*' teaching design match their lesson plan presentation?		
		2. Is the theoretical basis of the *Pre-Service Teacher Students*' lesson plan presentation objective and accurate?		
	Norm	**3. Does the *Pre-Service Teacher Students*' grooming meet the requirements?**		
		4. Are *Pre-Service Teacher Students*' verbal representations up to requirements?		
		5. Are *Pre-Service Teacher Students*' nonverbal representations up to requirements?		
	Cognition	6. How well do the *Pre-Service Teacher Students* grasp the chemistry curriculum standards?		
		7. How well do *Pre-Service Teacher Students* grasp chemistry textbooks' content and organization logic?		

		8. What is the *Pre-Service Teacher Students*' level of chemical scientific and chemical teaching thinking?		
Pre-Service Teacher Students Teaching	Section	9. Does the content of each section of the teaching design serve the teaching objectives?		
		10. Are the teaching or experimental sections conducive to student understanding?		
	Presentation	11. Are the lesson plan presentation and the explanation process clear and accurate?		
		12. Are the blackboard writing, multimedia, etc., presentations complete and accurate?		
		13. Is the experimental content part standardized and safe?		
	Dialogue	**14. Could teachers communicate with the majority of students?**		
		15. Are there enough exchanges between teachers and students in the lesson?		
		16. Is there value in communication in teaching design?		
	Guidance	17. Does the teacher give appropriate guidance while teaching?		
		18. Is the teacher's guidance on student experimental part patient and meticulous?		
	Wit	19. How do the *Pre-Service Teacher Students* handle the unexpected situation?		
		20. How well do the *Pre-Service Teacher Students* grasp the overall course rhythm?		
Curriculum	Objective	21. Are the design of teaching objectives justified?		
		22. Are the selection of teaching key points and difficulties of the course justified?		
	Content	23. Does this lesson's content meet the required scenario?		
		24. Is the content organized by the cognitive patterns of students in the "Academic Quality Levels"?		
		25. Does the teaching design take care to relate to real-life situations and practical problems?		
	Implementation	26. Is the teaching process consistent with the lesson plan presentation and achieving the expected effect?		
		27. Are activities appropriate and conducive to stimulating students' interest in learning?		
		28. Is the logic of teaching knowledge points conducive to students' transfer and application?		
	Evaluation	29. Is the teacher evaluating students timely and motivating?		
		30. Does the teacher's evaluation promote the implementation of teaching objectives?		

	Resources	**31. Does the teacher make full use of various teaching resources?**		
		32. Does the experimental part embody the values of green chemistry?		
Culture	Reflection	33. Does the guidance in the teaching design help students develop disciplinary thinking in chemistry?		
		34. Does the guidance process contribute to students' problems and scientific consciousness?		
	Democracy	35. Does the teaching design adhere to the principle of student-centeredness?		
		36. Are the communications between teachers and students equal and harmonious?		
	Innovation	37. What innovative points are in the teaching design?		
		38. Does the teaching process help students generate new questions?		
	Characteristic	39. Does the entire simulated teaching have highlights?		
		40. Do the *Pre-Service Teacher Students* demonstrate any highlights throughout the process?		
	Inquiry	41. Does the teacher guide students in independent inquiry?		
		42. Is the guidance process conducive to enhancing their innovation consciousness?		
Total Score				

3.4.2. Views and Modifications Based on the Second Round of Expert Consultation

After experimental observation, the author consulted with mentors, experts in chemistry education, and front-line middle school chemistry teachers online and offline. After several rounds of communication, the author received revision suggestions. The author collected and analyzed the specific revision suggestions and found two main problems with the scale that could be solved. The first part is that the description of some observation points needs to be clarified, and the second part is that some observation points need to be better integrated with the *Chemistry Core Competencies*. Now, based on the revision suggestions from the teachers, the summary of the confirmed observation point modifications is as follows:

Table 3.3 Summary of Modifications

Before	After
13. Is the experimental content part standardized and safe?	13. Is the experimental content part standardized, safe, and green? Due to the restructuring of observation point 32, the requirements for green chemistry in level 4 of "Scientific Attitude and Social Responsibility" have been merged into observation point 13. the observation points for the experimental part are mainly based on the requirements of "scientific attitude and social responsibility," safety awareness, rigorous and realistic scientific attitude, "green chemistry" thinking, etc
Guidance: Because each student's acceptance status differs, one-on-one teacher guidance is essential. However, the teacher can only care for some students because the classroom teaching time is limited. Hence, the teacher needs to be good at observing which students have questions or operation errors. When guiding, you also need to pay attention to the method. Rough and impatient guidance may discourage students and make them lose interest in chemistry. Therefore, research must observe: Does the teacher give appropriate guidance while teaching? Is the teacher's guidance on student experimental part patient and meticulous?	**Guidance:** Most students are still in the stage of memorizing and simply applying chemical knowledge, and they need help forming a complete chemical knowledge framework. Therefore, teachers need to provide appropriate guidance in teaching and experiments, combining the unique characteristics of chemistry. The method of guidance also needs to be noted. Rough and impatient guidance may discourage students and make them lose interest in chemistry. Therefore, research must observe: Have the teaching process been appropriately guided based on macro, micro, or model perspectives? Has appropriate guidance been provided in the experimental part based on evidence or chemical changes? the observation points of the characteristics of the chemistry discipline are based on the three *Chemistry Core Competencies*: "Macro Identification and Micro Analysis," "Change Concept and Balance Thought," and "Evidence Reasoning and Model Cognition." Macro-micro and change are the core ideas of the discipline of chemistry, and evidence is essential for scientific inquiry.

Resources: According to the curriculum standards, teachers must strive to develop chemical teaching resources. At the same time, according to the requirements of green chemistry in Level 4 of ″Scientific Attitude and Social Responsibility,″ *research needs* to save the drugs used in the experiment. Therefore, research needs to observe: Does the experimental part embody the values of green chemistry? Does the teacher make full use of various teaching resources?	**Resources:** According to the new curriculum's requirements, teachers must strive to develop chemical teaching resources. However, using resources is essential to teaching and cannot replace teaching. The people must not be greedy and put the cart before the horse. So, research must observe: Are the *PST-Students* reasonably using various chemical teaching resources? Do the resources presented in the teaching design help students explore and innovate independently? Resources are a teaching tool. Good use of resources can achieve twice the result with half the effort, save teaching costs, and stimulate students' desire to explore and innovate to meet better the requirements of "scientific inquiry and innovation awareness," a core chemistry competency.
Inquiry: Inquiry-based learning is an active learning process where students explore questions independently during science classes. This aligns with the expectations of ″scientific inquiry and innovation consciousness″ and ″scientific attitude and social responsibility.″ therefore, research must observe: Does the teacher guide students in independent inquiry? Is the guidance process conducive to enhancing their innovation consciousness?	Inquiry: Inquiry-based learning is an active learning process, referring to how students independently explore problems in science classes. Based on the students' active initiative, appropriate guidance from teachers can achieve twice the result with half the effort. This is also the common expectation of ″scientific inquiry and innovation awareness″ and ″scientific attitude and social responsibility.″ therefore, research must observe: Is appropriate guidance provided in the teaching process to inspire students to explore independently? Is appropriate guidance in the experimental part to encourage students to relate to life?

3.4.3. Determination of Observation Scales

Based on the specific revision suggestions proposed by various experts and scholars, the diagram displays the final reconstructed observation scale system (4 observation dimensions, 18 observation perspectives, 42 observation points) by supplementing, merging, and deleting observation content.

Table 3.4 The Final Version of The Observation Scale

Topic	

Name		Time of lesson plan presentation		Averag e Score
Time		Whether the lesson plan presentation takes place before or after the course ends.		
Observatio n Dimension	Observation Perspective	Observation Opinions	Score (1-5)	Score (1-5)
Pre-Service Teacher Students Learning	Preparation	1. Does the *Pre-Service Teacher Students*' teaching design match their lesson plan presentation?		
		2. Is the theoretical basis of the *Pre-Service Teacher Students*' lesson plan presentation objective and accurate?		
	Norm	3. Does the *Pre-Service Teacher Students*' grooming meet the requirements?		
		4. Are *Pre-Service Teacher Students*' verbal representations up to requirements?		
		5. Are *Pre-Service Teacher Students*' nonverbal representations up to requirements?		
	Cognition	6. How well do the *Pre-Service Teacher Students* grasp the chemistry curriculum standards?		
		7. How well do *Pre-Service Teacher Students* grasp chemistry textbooks' content and organization logic?		
		8. What is the *Pre-Service Teacher Students*' level of chemical scientific and chemical teaching thinking?		
Pre-Service Teacher Students Teaching	Section	9. Does the content of each section of the teaching design serve the teaching objectives?		
		10. Are the teaching or experimental sections conducive to student understanding?		
	Presentation	11. Are the lesson plan presentation and the explanation process clear and accurate?		
		12. Are the blackboard writing, multimedia, etc., presentations complete and accurate?		
		13. Is the experimental content part standardized, safe, and green?		
	Dialogue	14. Could teachers communicate with the majority of students?		

		15. Are there enough exchanges between teachers and students in the lesson?		
		16. Is there value in communication in teaching design?		
	Guidance	**17. Have the teaching process been appropriately guided based on macro, micro, or model perspectives?**		
		18. Have appropriate guidance been provided in the experimental part based on evidence or chemical changes?		
	Wit	19. How do the *Pre-Service Teacher Students* handle the unexpected situation?		
		20. How well do the *Pre-Service Teacher Students* grasp the overall course rhythm?		
Curriculum	Objective	21. Are the design of teaching objectives justified?		
		22. Are the selection of teaching key points and difficulties of the course justified?		
	Content	23. Does this lesson's content meet the required scenario?		
		24. Is the content organized by the cognitive patterns of students in the ″Academic Quality Levels″?		
		25. Does the teaching design take care to relate to real-life situations and practical problems?		
	Implementation	26. Is the teaching process consistent with the lesson plan presentation and achieving the expected effect?		
		27. Are activities appropriate and conducive to stimulating students' interest in learning?		
		28. Is the logic of teaching knowledge points conducive to students' transfer and application?		
	Evaluation	29. Is the teacher evaluating students timely and motivating?		
		30. Does the teacher's evaluation promote the implementation of teaching objectives?		
	Resources	**31. Are the *Pre-Service Teacher Students* reasonably used various chemical teaching resources?**		

		32. Do the resources presented in the teaching design help students explore and innovate independently?		
Culture	Reflection	33. Does the guidance in the teaching design help students develop disciplinary thinking in chemistry?		
		34. Does the guidance process contribute to students' problems and scientific consciousness?		
	Democracy	35. Does the teaching design adhere to the principle of student-centeredness?		
		36. Are the communications between teachers and students equal and harmonious?		
	Innovation	37. What innovative points are in the teaching design?		
		38. Does the teaching process help students generate new questions?		
	Characteristic	39. Does the entire simulated teaching have highlights?		
		40. Do the *Pre-Service Teacher Students* demonstrate any highlights throughout the process?		
	Inquiry	**41. Is appropriate guidance provided in the teaching process to inspire students to explore independently?**		
		42. Is appropriate guidance provided in the experimental part to inspire students to relate to life?		
Total Score				

3.4.4. Instructions for Using the Observation Scale

All five aspects of students' *Chemistry Core Competencies* are equally important, and their status on the scale is similarly high. Cultivating students' Competencies is a continuous and progressive process, and research should not neglect one aspect over another or be biased. People should pay equal attention to each observation point. Therefore, the total score of the 18 observation perspectives in the scale is set at 5 points, and the total score of each observation point under the observation perspective is also 5 points. The final score of the observation perspective is the average score of the observation points to which it belongs. The final score is obtained by adding up the scores of all observation perspectives, with a total score of 90 points. The specific scoring standard is borrowed from the Likert scale's 5-1 point standard, which can be divided into five levels: very consistent, consistent, general, basically inconsistent, and no characteristics consistent, corresponding to 5 points to 1 point, respectively.

Observers can judge the implementation level of the *Chemistry Core Competencies* in the classroom based on the final score. If the total score is >72 points (80% of the total score), it is considered that the implementation level of the *Chemistry Core Competencies* in this class is high and excellent. If the total score is >54 points (60% of the total score), it is considered that the implementation level of the *Chemistry Core Competencies* in this class is qualified. If the total score is <54 points (60% of the total score), it is considered that the implementation level of the *Chemistry Core Competencies* in this class could be better and more qualified. (He, 2022)

In the actual application process of the observation scale, it is necessary to strictly follow the requirements of the *LICC-Paradigm* and proceed in the mode of ″pre-class meeting - in-class observation - post-class meeting.″ In the pre-class meeting, the observed *PST-Students* will give a lecture and show the teaching design of this class so that everyone can understand the critical content of the lecture in advance and make a mark on the observation scale. During the in-class observation, observers must focus and objectively score each observation point on the scale. After the class meeting, observers will evaluate the class based on their observation scales, find out the highlights and shortcomings of the class, and pay attention to closely combining the *Chemistry Core Competencies* when evaluating. After the evaluation, the *PST-Students* need to reflect on themselves, reflect on the areas they need to improve in this class and how to improve them on a micro level, and reflect on the shortcomings of their teaching methods or class status on a macro level, striving to improve their teaching in all aspects through one class observation and achieve an overall improvement in the level of classroom teaching.

3.5. Tests of the Observation Scale

The constructed observation scale is based on the expert review method and is applied in the actual micro-classroom of *PST-Students*. The collected data is analyzed and studied using statistical methods to determine the reliability and validity of the scale.

3.5.1. Validity Tests for Observation Scales

Validity is the central extent to which a concept, conclusion, or measurement is well-founded and likely corresponds accurately to the real world. The word"valid" is derived from the Latin validus, meaning strong. The validity of a measurement tool(for example, an education test)is the degree to which the tool measures what it claims to measure.

3.5.1.1. Composition of the Group of Experts

This study has undergone two rounds of expert revisions. During the two rounds of revisions, an expert group was organized to evaluate the validity of the observation scale. The specialist group teachers' experience, education, and titles all affect the expert opinions' authority. The experts invited in this study are divided into two categories: the first category invites four teachers from the discipline of Chemistry and Curriculum teaching theory at Yunnan Normal University. These teachers always grasp the latest developments in chemistry, have conducted detailed research on the teaching concepts, *Core Competencies*, and new requirements for education in the new curriculum standards, and have unique insights. At the same time, their many years of scientific research and teaching experience have given them some understanding of classroom teaching evaluations at home and abroad, and their opinions are significant for the evaluation research currently being explored. The second category invites six front-line middle school teachers. They have attended various major chemistry teacher-teaching competitions many times and are familiar with classroom teaching evaluations. Multiple schools have attached great importance to teaching *Core Competencies* in recent years. These teachers are on the front line of chemistry teaching and can provide constructive opinions. Now, their basic information is summarized as follows:

Table 3.5 Summary of Information on The Members of The Group of Experts

Number	Qualification	Title	Workplace
A	PhD degree	Full Professor	University
B	PhD degree	Associate Professor	University
C	Master degree	Associate Professor	University
D	Master degree	Associate Professor	University
E	Master degree	Intermediate Teacher	Senior High School
F	Master degree	Intermediate Teacher	Senior High School
G	Bachelor's degree	Associate Senior Teacher	Senior High School

H	Bachelor's degree	Associate Senior Teacher	Senior High School
I	Bachelor's degree	Intermediate Teacher	Senior High School
J	Bachelor's degree	Intermediate Teacher	Senior High School

3.5.1.2. Validity Analysis

The validity test of the scale designed in this article uses the expert review method. By making a consultation form, four senior high school chemistry teachers with rich teaching experience and six professors in the direction of chemistry teaching are invited to test the correlation between each index of the scale and the content measured. There are no weak overlapping observation points in the results, so the validity of this scale is relatively high. The specific consultation form can be seen in the appendix. The review results are shown in the following table. (The Group of Experts Review Scale, see Appendix C)

Table 3.6 Effectiveness Results of The Group of Experts Review Scale

Number	Strong Correlation	Weak Correlation
A	36	3
B	33	0
C	26	3
D	42	0
E	37	1
F	30	0
G	19	4
H	32	4
I	35	1
J	38	1

For each weakly related observation point selected by each teacher, the author asked the teacher for suggestions for improvement and made two revisions to the scale. The specific modification content for each weak observation point is written in section 3.4.2 of this paper based on the opinions and modifications of the second round of expert consultation.

3.5.2. Reliability Tests for Observation Scales

Reliability is the overall consistency of a measure. A measure is highly reliable if it produces similar results under consistent conditions.

3.5.2.1. Information about the observer and observed

The author invited two graduate students from the chemistry education direction of Chinese normal universities to serve as evaluators, who independently observed and scored. The evaluation class example is about 15 minutes of *PST-Students* simulation teaching (including lesson planning), comprising five classes.

The observers are undergraduate students in chemistry education at normal Chinese universities. The people randomly selected five students in the classroom for observation and recording.

3.5.2.2. Reliability Analysis

The actual evaluation environment of this study invited two independent evaluators (including the author, a total of three people) to score five different class examples. The specific results are as follows:

Table 3.7 Summary of The Evaluation of Five Lessons by Observer 1

Observation Dimension	Observation Perspective	Lesson1	Lesson2	Lesson3	Lesson4	Lesson5
Pre-Service Teacher Students Learning	Preparation	5	3	4	4	4
	Norm	5	3	3	4	4
	Cognition	5	3	3	3	4
Pre-Service Teacher Students Teaching	Section	5	2	2	3	4
	Presentation	5	3	3	4	4
	Dialogue	5	2	3	4	3
	Guidance	5	2	3	4	4
	Wit	5	2	2	4	3
Curriculum	Objective	5	4	3	4	4
	Content	5	2	3	3	4
	Implementation	5	2	3	3	4
	Evaluation	5	1	2	3	4
	Resources	5	3	3	3	4

Culture	Reflection	5	2	1	3	4
	Democracy	4	1	3	4	4
	Innovation	5	1	3	3	3
	Characteristic	5	1	2	2	3
	Inquiry	5	1	3	3	3

Table 3.8 Summary of The Evaluation of Five Lessons by Observer 2

Observation Dimension	Observation Perspective	Lesson1	Lesson2	Lesson3	Lesson4	Lesson5
Pre-Service Teacher Students Learning	Preparation	5	3	3	3	4
	Norm	5	2	3	4	4
	Cognition	5	3	3	4	4
Pre-Service Teacher Students Teaching	Section	5	1	3	4	4
	Presentation	5	1	3	3	3
	Dialogue	5	2	2	3	4
	Guidance	5	3	3	3	4
	Wit	5	2	3	3	4
Curriculum	Objective	5	3	3	4	3
	Content	5	2	3	4	4
	Implementation	5	2	2	4	4
	Evaluation	5	2	2	3	4
	Resources	5	2	3	3	4
Culture	Reflection	5	1	3	3	3
	Democracy	4	2	3	4	4
	Innovation	5	2	2	2	4
	Characteristic	5	2	2	3	3
	Inquiry	5	1	2	3	3

Table 3.9 Summary of The Evaluation of Five Lessons by Observer 3

Observation Dimension	Observation Perspective	Lesson1	Lesson2	Lesson3	Lesson4	Lesson5
Pre-Service	Preparation	5	2	3	4	4

Teacher Students Learning	Norm	5	4	4	4	3
	Cognition	5	3	3	4	4
Pre-Service Teacher Students Teaching	Section	5	1	3	3	4
	Presentation	4	3	2	3	3
	Dialogue	5	2	3	3	3
	Guidance	5	2	3	4	4
	Wit	5	3	2	3	3
Curriculum	Objective	5	3	4	4	4
	Content	5	1	3	4	4
	Implementation	5	1	3	3	4
	Evaluation	5	1	3	2	4
	Resources	5	2	2	3	5
Culture	Reflection	5	1	2	3	4
	Democracy	5	2	2	3	4
	Innovation	5	1	2	3	3
	Characteristic	4	1	2	3	3
	Inquiry	5	2	2	4	3

Table 3.10 Summary of The Total Observation Scores from Three Observers in Five Lessons

	Lesson1	Lesson2	Lesson3	Lesson4	Lesson5
Observer1	89	38	49	61	67
Observer2	89	36	48	60	67
Observer3	88	35	48	60	66

Cronbach's alpha is a method of test reliability. (Cronbach, 1951) It evaluates the consistency within the test based on a specific formula. Kendall's W coefficient can usually measure the consistency between multiple evaluators. (Kendall & Smith, 1939) The larger the Kendall coefficient value, the better the consistency between different evaluators. Intraclass correlation coefficient (hereinafter referred to as ICC) is a descriptive statistic used when quantitative measurements are made on units organized into groups. (Bartko, 1966) Prominent application is the assessment of consistency or reproducibility of quantitative measurements made by different observers measuring the same quantity.

The values of Cronbach's Alpha coefficient range from 0 ~ 1. It is generally considered acceptable if it is above 0.70, good if it is above 0.80, and excellent if it is above 0.90. The Kendall's W coefficient ranges from 0 ~ 1. Generally, the consistency of 0.40 ~ 0.60 is moderate, 0.60 ~ 0.80 is good, and 0.80 to 1.00 is very strong. The ICC value ranges from 0 to 1. It is generally considered that a consistency of 0.50 ~ 0.75 is moderate, 0.75 ~ 0.90 is good, and 0.90 ~ 1.00 is very strong.

Using SPSS data analysis software to analyze Cronbach's Alpha reliability coefficient, Kendall's W coefficient, and ICC of the scores of the four evaluators, as shown in the following table:

Observation Dimension	Observation Perspective	Scores	Total Score
Pre-Service Teacher Students Learning	Preparation Norm Cognition	0.934	0.986
Pre-Service Teacher Students Teaching	Section Presentation Dialogue Guidance Wit	0.973	
Curriculum	Objective Content Implementation Evaluation Resources	0.951	
Culture	Reflection Democracy Innovation Characteristic Inquiry	0.950	

Table 3.11 Test Situation of Cronbach's Alpha Coefficient for Observer 1

Table 3.12 Test Situation of Cronbach's Alpha Coefficient for Observer 2

Observation Dimension	Observation Perspective	Scores	Total Score
Pre-Service Teacher	Preparation	0.940	0.990

Students Learning	Norm Cognition		
Pre-Service Teacher Students Teaching	Section Presentation Dialogue Guidance Wit	0.963	
Curriculum	Objective Content Implementation Evaluation Resources	0.964	
Culture	Reflection Democracy Innovation Characteristic Inquiry	0.952	

Table 3.13 Test Situation of Cronbach's Alpha Coefficient for Observer 3

Observation Dimension	Observation Perspective	Scores	Total Score
Pre-Service Teacher Students Learning	Preparation Norm Cognition	0.792	0.984
Pre-Service Teacher Students Teaching	Section Presentation Dialogue Guidance Wit	0.926	
Curriculum	Objective Content Implementation Evaluation Resources	0.955	
Culture	Reflection	0.981	

Democracy
Innovation
Characteristic
Inquiry

Table 3.14 Test Situation for The Three Observers

ICC (C, k) Two-way mixed, consistent, and average measurement	Kendall's W Coefficient
0.878	1.000

As all the data shown earlier indicates, except for the Cronbach's Alpha coefficient of *PST-Students* Learning Observation Dimension by Observer 3, which is above 0.70, the Cronbach's Alpha coefficients for each observation dimension and the total observation scale of each observer are all above 0.90. This suggests that the scale has good internal consistency. The ICC (C, k) is above 0.75, and Kendall's W coefficient has reached a satisfactory 1.000, indicating that the observation consistency among the three observers is exceptionally high. The results of the three reliability tests show that the scale has sound reliability effects.

Chapter4. Application of Classroom Observation Scale Based on Discipline *Core Competencies* in Chemistry

The original intention of creating the scale is to apply it to the actual teaching of *PST-Students* and to score the learning and simulated teaching situations of *PST-Students* preliminarily. In an environment without teacher comments, *PST-Students* can conduct evidence-based and opinionated peer reviews based on the scale and then analyze the classroom based on the results. The purpose is to allow *PST-Students* to discover their shortcomings in simulated teaching during the analysis process and improve their shortcomings in time, promote mutual teaching and learning, make collective progress, and ultimately truly highlight the *Chemistry Core Competencies* in the teaching of every daily class.

4.1. Selection of the Study Sample

The samples used in this study are undergraduate *PST-Students* from the 2020 and 2021 classes of the Faculty of Chemistry and Chemical Engineering at Yunnan Normal University (Kunming, China). The author collaborated with Professor Chen Jiping and selected two classes from his course, ″Chemistry Classroom Teaching Skills Training and Evaluation,″ for actual observation. The evaluation examples are about 15 minutes of *PST-Students*' simulated teaching (including lesson plan presentation). We observed a total of 42 students.

4.2. Practical Observations of *PST-Students* Simulated Teaching

4.2.1. Application Process

The actual application of the observation scale in this study strictly followed the requirements of the *LICC-Paradigm*. It was conducted in the mode of ″pre-class meeting - in-class observation - post-class meeting″ (for specific usage, see the instructions for using the observation scale in section 3.4.4).

By the syllabus and evaluation requirements of the course ″Chemistry Classroom Teaching Skills Training and Evaluation,″ Professor Chen Jiping explained his evaluation criteria to the students at the beginning of the semester. Based on these requirements and combined with the *Chemistry Core Competencies*, he conducted evaluations in the mode of ″pre-class meeting - in-class observation - post-class meeting.″ the evaluation results were also scored, with a total score of 100 points.

The author and Professor Chen Jiping conducted observations at the same place and time. After the course ended, interviews and discussions were conducted. The results of the two groups corroborated each other, forming a method of Triangulation. (Denzin, 2012)

4.2.2. Observational Data and Analysis

The observation results are shown in the following Table4.1.

Table 4.1 Summary of The Total Observation Scores from Two Observers in Forty-two Lessons

Student Number	Prof.Chen Jiping	The Author
S1	92	89
S2	92	88
S3	92	85
S4	92	82
S5	90	82
S6	92	80
S7	91	80
S8	91	79
S9	90	77
S10	91	74
S11	90	74
S12	90	73
S13	90	72
S14	90	72
S15	89	72
S16	89	72
S17	89	70
S18	88	70
S19	89	69
S20	89	69
S21	89	68
S22	88	68
S23	88	66
S24	88	65

S25	86	65
S26	87	63
S27	88	61
S28	87	61
S29	87	60
S30	86	59
S31	85	58
S32	85	58
S33	84	58
S34	84	57
S35	83	53
S36	82	51
S37	81	50
S38	80	49
S39	79	48
S40	76	48
S41	76	47
S42	72	47

Following the same procedure, the author uses SPSS to conduct reliability tests on the obtained data using ICC and Kendall's W coefficient. The results are shown in the following Table 4.2.

Table 4.2 Test Situation for The Two Observers

ICC (C, k) Two-way mixed, consistent, and average measurement	Kendall's W Coefficient
0.775	0.990

As all the data shown earlier indicates, the ICC (C, k) is above 0.75. Kendall's W coefficient has reached a satisfactory 1.000, indicating that the observation consistency among the three observers is exceptionally high. The results of the three reliability tests show that the scale has sound reliability effects.

4.2.3. Observed Results

According to the author's observation, 16 students (38.10%) have implemented *Core Competencies* very well, reaching an excellent level. In addition, 18 students (34 students, 80.95%) have implemented *Core Competencies* reasonably well, reaching a qualified level. However, there are still 8 students (19.05%) whose implementation of *Core Competencies* could be better at an unqualified level.

After class, the author also had in-depth discussions and exchanges with Professor Chen Jiping. The observation results objectively and genuinely reflect the current teaching level of the students and their understanding and application level of *Core Competencies*. Since the author was observing, the teaching work for this semester has yet to be completed, so it is understandable and acceptable that some students did not perform well. After the end of the semester, I revisited Professor Chen Jiping, who stated that all students have met the corresponding requirements of the course and completed the course.

This research uses two different observation methods to form a Methods triangulation. From the above observation results, we can see that after the overall practical application, it proves that the observation scale constructed by this study has specific application value and practical significance.

4.2.4. Teaching and Learning Recommendations

After observing dozens of *PST-Students*' simulated classrooms, the author finds that most *PST-Students* can implement *Core Competencies* reasonably well during the teaching process to meet the curriculum standard requirements and other guiding documents. However, implementing most *Core Competencies* mainly focuses on the knowledge level, and cultivating abilities needs to be revised. The main manifestations are that *PST-Students* have too much control over the classroom, need more guidance for student thinking, and have a single logic for using teaching resources. In response to the above problems, the author combines the views of two other independent observers and proposes the following teaching opinions and suggestions:

First, teachers need to add connections between knowledge and life. When preparing lessons, teachers not only need to analyze students and textbooks but also need to have a particular understanding of the application of this part of knowledge in life. Only when the teacher has a deep and extensive experience of this part of knowledge can they give students more appropriate guidance in the classroom? This makes it easier for students to transfer knowledge and is more conducive to forming students' chemical thinking.

Second, teachers should dare to let go and hand the classroom to students. Teachers can use techniques such as situational teaching and leave the problem to students during the teaching process. They use various means to set up progressive links to inspire students to think instead of setting up questions too directly.

Finally, teachers should be good at using chemical teaching resources. Resources serve the classroom and enrich the icing on the cake, not some time-saving and labor-saving substitutes. When using resources, teachers should set goals and not let students use them directly and rudely.

Chapter5. Discussion and Conclusion

5.1. Conclusions of the research

The research's main work starts from the *Core Competencies* perspective, uses the classroom observation LICC paradigm as a template, combines *Chemistry Core Competencies*, and constructs a simulated classroom observation scale for *PST-Students*. Five classes are selected for reliability and validity testing, and forty-two *PST-Students* are observed on-site as practical applications. The following conclusions are drawn after analyzing the research results.

After multiple expert opinion surveys and improvements, the research constructs a relatively scientific, reasonable, effective, and practical 4 dimensions, 19 observation perspectives, and 442 observation points of the teacher-student simulated classroom observation scale. After multiple reliability and validity tests, Cronbach's Alpha coefficient, ICC (C, k), and Kendall's W Coefficient results prove that this scale has good internal and user consistency.

The research provides a reference and usable tool for evaluating teacher-student simulated classrooms. The author finds during his undergraduate studies that the current *PST-Students* simulated classroom activities lack a certain degree of standardization, so a scientific and efficient classroom observation scale effectively improves the efficiency of classroom observation. A specialized classroom observation scale is constructed. The third chapter of this article details the design and construction process of the classroom observation scale, determining the observation dimensions, perspectives, and points. After multiple reliability and validity tests, it proves that this scale has high practical value and can also provide a specific reference value for subsequent researchers to construct a classroom observation scale.

The research realizes the function of evaluation and feedback. Observers analyze the *PST-Students* simulated classroom in detail through the forty-two observation points of the scale, can find problems in the classroom and make suggestions, and to a certain extent, realize the function of evaluation and feedback.

5.2. Insufficient research

A good classroom observation scale requires long-term repeated verification, but this goal cannot be achieved due to time constraints. In addition, the author's understanding of *Core Competencies* and *Chemistry Core Competencies* is not comprehensive enough, so the authority of the final constructed scale remains to be considered. In addition, when the author conducts reliability and validity tests, only two independent observers are invited to observe 5 classes together. There is a lack of personnel and sample size, so the reliability and validity test needs to be improved.

Due to time constraints, after making teaching suggestions to the observed *PST-Students*, there needs to be a follow-up observation on whether the Pre-Service Teacher Student has corrected all the deficiencies in teaching in subsequent classroom teaching. Therefore, we need to find out whether the suggestions for this scale suit the observed students and whether they have genuinely improved the quality of classroom teaching.

Observers generally believe this scale needs to be more comprehensive and detailed during the observation process and is unsuitable for various types of high school chemistry classroom observations. The scale requires evaluators to observe too many points, the workload of observers is too large, and they cannot accurately and timely grasp the highlights in the classroom.

5.3. Research Perspectives

The author firmly believes in the value of this research and looks forward to further improving this study in future learning, work, and research life.

The author strives to combine with case studies and conduct long-term follow-up observations on the observed subjects, hoping to achieve more excellent practical application value. Different observation scales should be designed for various types of courses, focusing on different observation points that are more targeted and effective.

In the pre-class meeting, the observed teacher narrates the teaching design, but other observer teachers must make reasonable suggestions for the teaching arrangement. The role of the pre-class meeting can be appropriately improved, turning it into a process where everyone brainstorms together to design a lesson, which promotes the improvement of the classroom. On this basis, further classroom observations are conducted, and the conclusions drawn are more valuable.

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Appendix A

Table 5.1 Level Division of Discipline Core Competencies in Chemistry

Level	1. Macro Identification and Micro Analysis
Level 1	One can identify substances and their reactions based on experimental phenomena, use chemical symbols to describe common simple substances and their changes, classify and characterize substances and their reactions from the macroscopic characteristics of substances, and explain macroscopic phenomena in connection with the composition and structure of substances.
Level 2	The translation of the text is: “can generalize the types of substances and their reactions. One can use particle structure diagrams to describe the process of substance changes. From the microscopic structure of substances, one can explain the commonality of the same type of substances and the differences in properties of different types of substances and their causes. One can also explain the laws of property changes of different substances of the same type.
Level 3	One can analyze the microscopic characteristics of common substances and their reactions at the atomic and molecular levels. One can use chemical symbols and quantitative calculations to explain the composition of substances and their changes. One can analyze the relationship between the chemical changes of substances, the accompanying energy transformation, and the microscopic structure of substances.
Level 4	Based on the microscopic structure of substances, one can describe or predict the properties of substances and the chemical changes that may occur under certain conditions. One can evaluate the rationality of specific explanations or predictions. From the perspective of macro-micro integration, one can classify and characterize substances and their changes.

Level	2. Concept of Change and Balance Thought
Level 1	The ability to recognize that the movement and change of matter are eternal; to summarize the commonalities and characteristics of matter and its changes; to understand that energy changes accompany chemical changes; to summarize the conditions, characteristics, and laws of chemical changes based on observations and experimental data.
Level 2	The ability to analyze the internal causes and the essence of chemical changes from the atomic and molecular level, to understand the relationship between quantitative and qualitative changes in chemical reactions, to view and analyze chemical changes from the perspective of mass conservation and dynamic equilibrium; to use chemical stoichiometric units to analyze chemical changes and the accompanying energy conversion quantitatively.
Level 3	The concept that chemical changes are conditional, understanding the impact of reaction conditions on the rate of chemical reactions and equilibrium, using the

Level 4	principles of chemical reactions to analyze the factors affecting chemical changes, and learning to use variable control methods to study chemical reactions. Able to understand the diversity of chemical changes from different perspectives, able to use the idea of the unity of opposites and the combination of qualitative and quantitative methods to reveal the essential characteristics of chemical changes; able to explain or predict the properties and chemical changes of specific substances, able to use the laws of chemical changes to analyze and explain chemical changes in production and real life.

Level	3. Evidence Reasoning and Model Cognition
Level 1	Able to extract evidence from the facts of matter and its changes, propose hypotheses for related chemical problems, and prove or falsify hypotheses based on evidence; able to identify common material models in chemistry and theoretical models of chemical reactions, and able to associate and reasonably match between chemical facts and theoretical models.
Level 2	Able to collect evidence from both macroscopic and microscopic perspectives, analyze problems from different angles based on evidence, and draw reasonable conclusions; able to understand, describe, and represent common cognitive models in chemistry, point out the specific meaning of the model representation, and apply it to theoretical models to explain or speculate on the composition, structure, properties, and changes of matter.
Level 3	Able to collect evidence by combining qualitative and quantitative methods and draw reasonable conclusions through qualitative analysis and quantitative calculations; able to recognize the similarities and differences between theoretical models of matter and its changes and research objects and evaluate the relationship between models and prototypes to improve the model; able to clarify the conditions and scope of application of the model.
Level 4	Able to find sufficient evidence based on the different characteristics of various substances and their reactions and explain the relationship between evidence and conclusions; able to analyze the critical elements in complex chemical problem situations to construct corresponding models and choose different models to explain or solve complex chemical problems comprehensively; able to point out the limitations of the constructed model, and explore the evidence needed for model optimization.

Level	4. Scientific Inquiry and Innovation Awareness
Level 1	Able to design simple experimental plans based on the problems given in the textbook, complete the experimental operations, observe the phenomena of substances and their changes, objectively record, explain the experimental phenomena, and discover and propose problems that need further research.
Level 2	Able to propose possible hypotheses for solving simple chemical problems, design experimental plans based on hypotheses, assemble experimental instruments, cooperate with classmates to complete experimental operations, use

	various methods to collect experimental evidence, draw conclusions based on experimental facts, and put forward their views.
Level 3	Possesses a strong sense of problem awareness, able to propose investigative questions and hypotheses based on discussions with classmates, propose experimental plans based on hypotheses, independently complete experiments, collect experimental evidence, analyze phenomena and data and draw conclusions, and communicate their research results.
Level 4	Able to propose comprehensive research topics based on literature and practical needs, propose multiple research plans based on hypotheses, evaluate and optimize plans, and process experimental information using data, charts, symbols, etc. Able to reflect on abnormal phenomena and existing conclusions in the experiment, raise doubts and new experimental ideas, and further implement them.

Level	5. Scientific Attitude and Social Responsibility
Level 1	Possessing a sense of safety, gradually developing a rigorous and realistic scientific attitude, not superstitious, able to consciously resist pseudoscience; able to list facts to illustrate the significant contribution of chemistry to human civilization, actively care about social hot issues related to environmental protection and resource development, forming the concept of harmonious coexistence with the environment and rational use of natural resources.
Level 2	Advocating scientific truth, not superstitious about books and authority; possessing the concept of green chemistry, able to use the knowledge learned to analyze and discuss the dual impact that some chemical processes may bring to human health and sustainable social development, and evaluate these impacts from multiple aspects.
Level 3	Possessing the concept of linking theory with practice, conscious of applying chemical achievements to production and life, able to solve simple chemical problems in production and life based on actual conditions and using the learned chemical knowledge and methods; gradually forming concepts such as cost-saving, recycling, and environmental protection in practice.
Level 4	Respect scientific ethics, analyze a chemical process based on the concept of green chemistry and scientific ethics, weigh the pros and cons, and make reasonable decisions; propose specific solutions to various problems existing in some chemical process designs.

(Ministry of Education of China, 2020, pp.89-92)

Appendix B

Academic quality is the performance of academic achievement after students complete the course of this subject. The standard of academic quality is mainly based on the core competence of this subject and its performance level, combined with the course content, to give an overall portrayal of students' academic achievement performance. According to the key characteristics of academic achievement performance at different levels, the standard of academic quality divides academic quality into different levels. It describes the specific performance of learning outcomes at different levels. (Ministry of Education of China, 2020, p.64)

The level of academic quality in chemistry is divided into 4 levels. Each level description includes 5 aspects of the core competence of the chemistry subject, and it is divided into four items according to the emphasis of the content (the number in front of each item represents the level, and the number behind represents the item number). Each item (represented by numbers) corresponds to a specific core competence of the chemistry subject. For example, item 1 corresponds to Macro Identification and Micro Analysis and Evidence Reasoning and Model Cognition; item 2 corresponds to Concept of Change and Balance Thought; item 3 corresponds to Scientific Inquiry and Innovation Awareness; item 4 corresponds to Scientific Attitude and Social Responsibility. (Ministry of Education of China, 2020, p.64)

Table 5.2 The Level of Academic Quality in Chemistry

Level	Academic Quality in Chemistry
1	1-1 Able to classify substances based on their composition and properties, forming the view that substances are composed of elements and that elements remain unchanged in chemical reactions. Able to use atomic structure models to explain the properties of typical metals and non-metals. Able to describe and symbolize common substances (including simple organic compounds) and their changes. Able to understand the nature of ionic and redox reactions and can write ionic and chemical equations for redox reactions with examples. Able to explain the relationship between the properties and applications of common substances. 1-2 Recognize that chemical changes are conditional, can explain the mass relationship and energy conversion in chemical changes, can explain or explain the essential characteristics of chemical changes from the aspects of the composition of matter, the formation of particles, and the main properties. Recognize the critical role of the amount of substance in chemical quantitative research, combine experimental or actual data in production and life, and use the amount of substance to calculate the composition of the substance and the mass relationship in the process of substance transformation.

1-3 Able to choose standard experimental instruments, devices, and reagents according to the needs of solving chemical problems and complete simple experiments such as substance properties, preparation, and testing. Able to cooperate with partners to conduct experimental exploration, observe and record experimental phenomena truthfully, and form preliminary conclusions based on experimental phenomena.

1-4 Have safety awareness, can combine chemical knowledge with actual production and life; can actively care about and participate in discussions on social issues; appreciate the contributions of chemistry to human life and production; can use the learned chemical knowledge and methods to analyze and discuss simple chemical problems in production and life (such as acid rain prevention, environmental protection, food safety, etc.), and recognize the contribution of chemical science to sustainable social development.

2-1 Able to classify typical substances and their main changes from different perspectives; able to explain the trend of element properties from the perspective of atomic structure; able to explain the main properties of common substances from the aspects of particles that make up the substance, chemical bonds, functional groups, etc., and can analyze the relationship between substance properties and uses.

2-2 Able to analyze the reasons for energy absorption or release in chemical changes; recognize the diversity and complexity of chemical changes; can analyze the main factors affecting the rate of chemical reactions; can design the scheme of substance transformation; can use chemical symbols to characterize the transformation of substances, can explain the essential characteristics and change laws of chemical changes; can apply the law of conservation of mass to analyze the impact of substance transformation on resource utilization.

2 2-3 Able to explore the properties and change laws of substances through experiments, can propose meaningful experimental exploration questions, make predictions and assumptions based on existing experience and data, can design simple experimental schemes, can use appropriate methods to control reaction conditions and complete experiments; can collect and express experimental evidence, and draw conclusions based on experimental facts.

2-4 Able to analyze the value and contribution of chemical science in developing and utilizing natural resources, synthesizing new substances, protecting the environment, ensuring human health, promoting scientific and technological development and social civilization, etc.; understand the importance of following the green chemistry idea in chemical production, can understand food safety, environmental protection and other laws and regulations from the perspective of chemistry, pay attention to the possible negative impact of chemical products and technologies in production and life.

3-1 Able to understand the diversity of inorganic and organic compounds from
3 the aspects of composition and structure; able to classify substances from multiple
perspectives such as substance composition, properties, functional groups,
constituent particles, and interparticle forces; able to explain how differences in

substance composition, functional groups, and interparticle forces affect substance properties; able to classify chemical reactions from multiple angles, understand the essence of chemical reactions; able to use models, symbols and other methods to characterize the structure of substances and their changes comprehensively.

3-2 Able to explain the factors affecting the rate of chemical reactions and chemical equilibrium based on reaction rate theory and the principle of chemical equilibrium; able to describe and explain the essence and laws of substance transformation in macroscopic, microscopic, symbolic, and other ways; able to quantitatively analyze the thermal effects of chemical changes, analyze the principles of chemical energy and electrical energy conversion and their applications in production and life. Able to design the transformation and preparation of inorganic compounds, as well as the composition structure detection and synthesis of typical organic compounds according to the need to solve problems; able to analyze and evaluate the impact of substance transformation process on the environment.

3-3 Able to propose experimental exploration topics according to the need to solve problems; able to design experimental schemes to explore the transformation of substances and energy, factors affecting reaction rate and chemical equilibrium, main properties of organic compounds, etc.; able to choose appropriate experimental reagents and instrument devices, control experimental conditions, safely and smoothly complete experiments; able to collect and describe experimental evidence in various ways such as data and charts, and can make reasonable conclusions based on phenomena and data.

3-4 Able to explain the essential applications of energy transformation and reaction condition control in chemical changes in combination with actual production and life problem situations, recognize the critical contributions of organic compound transformation and synthesis to sustainable social and economic development, improving quality of life, etc.; able to use chemical principles and methods to explain or solve some practical problems related to chemistry in production and life; have an awareness of risk assessment for the promotion and application of chemical technology and the use of chemical products, can analyze the possible impact of chemical product production and application process on society and environment, can propose suggestions to reduce its negative impact.

4

4-1 Able to analyze and infer the substance and its changes from different perspectives according to the need in the context of substance and its changes; able to explain or predict the properties of substances based on the type, composition, structure of particles, and interparticle forces of substances, and evaluate the rationality of the explanations or predictions made; able to analyze and characterize the energy transformation in substance changes from macroscopic and microscopic, qualitative and quantitative angles; able to propose suggestions and opinions on the application of substances in production, life and science and technology based on the properties of substances.

4-2 Able to comprehensively analyze the conditions of the reaction from the aspects of controlling the reaction rate and improving the reaction conversion rate and propose effective measures to control the reaction conditions; able to choose concise and reasonable characterization methods to describe and explain the essence and laws of chemical changes, able to predict the products of substance transformation according to the principles of chemical reactions, and determine the evidence to verify the predictions made; able to propose practical suggestions for energy storage and release through chemical changes based on the principle of energy transformation in chemical changes; able to design the preparation of inorganic compounds and the synthesis of organic compounds based on the concept of "green chemistry," and evaluate and optimize the scheme; able to analyze and evaluate the impact of substance transformation process on the environment and resource utilization.

4-3 Able to list the experimental methods for determining the composition and structure of substances; able to infer the composition and structure of simple substances based on the data or charts of instrument analysis; able to propose valuable experimental exploration topics in the context of complex chemical problems, able to design comprehensive experimental schemes for substance transformation, separation, and purification, property application, etc.; able to use variable control methods to explore and determine appropriate reaction conditions, safely and smoothly complete experiments; able to describe experimental evidence with data, charts, symbols, etc., and form conclusions based on this analysis and reasoning; able to evaluate the experimental scheme, experimental process and experimental conclusions, and propose further exploration ideas.

4-4 Able to explain the critical role of the development of chemical science in the utilization of natural resources, material synthesis, environmental protection, safeguarding human health, promoting the development of science and technology, etc.; able to use chemical principles and methods to propose creative suggestions for solving hot issues in production and life, able to analyze and risk assess the promotion and application of chemical technology and the use of chemical products; able to analyze the problems existing in the production and application of some chemical products based on the concept of green chemistry, and propose solutions or solutions to chemical problems.

(Ministry of Education of China, 2020, pp.65-67)

Appendix C

Table 5.3 The Group of Experts Review Scale

The Group of Experts Review Scale				
Observation Dimension	Observation Perspective	Observation Opinions	Strong Correlation	Weak Correlation
Pre-Service Teacher Students Learning	Preparation	1. Does the *Pre-Service Teacher Students*' teaching design match their lesson plan presentation?		
		2. Is the theoretical basis of the *Pre-Service Teacher Students*' lesson plan presentation objective and accurate?		
	Norm	3. Does the *Pre-Service Teacher Students*' grooming meet the requirements?		
		4. Are *Pre-Service Teacher Students*' verbal representations up to requirements?		
		5. Are *Pre-Service Teacher Students*' nonverbal representations up to requirements?		
	Cognition	6. How well do the *Pre-Service Teacher Students* grasp the chemistry curriculum standards?		
		7. How well do *Pre-Service Teacher Students* grasp chemistry textbooks' content and organization logic?		
		8. What is the *Pre-Service Teacher Students*' level of chemical scientific and chemical teaching thinking?		
Pre-Service Teacher Students Teaching	Section	9. Does the content of each section of the teaching design serve the teaching objectives?		
		10. Are the teaching or experimental sections conducive to student understanding?		
	Presentation	11. Are the lesson plan presentation and the explanation process clear and accurate?		
		12. Are the blackboard writing, multimedia, etc., presentations complete and accurate?		
		13. Is the experimental content part standardized, safe, and green?		
	Dialogue	14. Could teachers communicate with the majority of students?		

		15. Are there enough exchanges between teachers and students in the lesson?		
		16. Is there value in communication in teaching design?		
	Guidance	17. Have the teaching process been appropriately guided based on macro, micro, or model perspectives?		
		18. Have appropriate guidance been provided in the experimental part based on evidence or chemical changes?		
	Wit	19. How do the *Pre-Service Teacher Students* handle the unexpected situation?		
		20. How well do the *Pre-Service Teacher Students* grasp the overall course rhythm?		
Curriculum	Objective	21. Are the design of teaching objectives justified?		
		22. Are the selection of teaching key points and difficulties of the course justified?		
	Content	23. Does this lesson's content meet the required scenario?		
		24. Is the content organized by the cognitive patterns of students in the "Academic Quality Levels"?		
		25. Does the teaching design take care to relate to real-life situations and practical problems?		
	Implementation	26. Is the teaching process consistent with the lesson plan presentation and achieving the expected effect?		
		27. Are activities appropriate and conducive to stimulating students' interest in learning?		
		28. Is the logic of teaching knowledge points conducive to students' transfer and application?		
	Evaluation	29. Is the teacher evaluating students timely and motivating?		
		30. Does the teacher's evaluation promote the implementation of teaching objectives?		
	Resources	31. Are the *Pre-Service Teacher Students* reasonably used various chemical teaching resources?		

		32. Do the resources presented in the teaching design help students explore and innovate independently?		
Culture	Reflection	33. Does the guidance in the teaching design help students develop disciplinary thinking in chemistry?		
		34. Does the guidance process contribute to students' problems and scientific consciousness?		
	Democracy	35. Does the teaching design adhere to the principle of student-centeredness?		
		36. Are the communications between teachers and students equal and harmonious?		
	Innovation	37. What innovative points are in the teaching design?		
		38. Does the teaching process help students generate new questions?		
	Characteristic	39. Does the entire simulated teaching have highlights?		
		40. Do the *Pre-Service Teacher Students* demonstrate any highlights throughout the process?		
	Inquiry	41. Is appropriate guidance provided in the teaching process to inspire students to explore independently?		
		42. Is appropriate guidance provided in the experimental part to inspire students to relate to life?		