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# Practice of Curriculum Teaching Reform in Higher Education under the Background of New Quality Productive Forces

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## Abstract

The proposition of "new quality productive forces" pointed out direction for the reform and development of China's higher education, and also put forward new and higher requirements for the cultivation of talents. Under this background, the authors conducted a practical exploration of curriculum teaching reform with the course of *Physical Chemistry* as an example. The reform involved two aspects: first, to promote ideological and political education through the reform of "Ke-Cheng Si-Zheng"; second, to enhance the cultivation of students' autonomous learning ability, critical thinking and creativity through the inquiry-based teaching reform. The reform was expected to make curriculum teaching more helpful in cultivating students to be "both virtuous and talented". The reform has achieved good results and has certain significance of promotion and reference.

## Keywords

New Quality Productive Forces, Ke-Cheng Si-Zheng, Inquiry-Based Teaching and Learning, Curriculum Reform, Higher Education

## 1. Introduction

In September 2023, during his inspection in Heilongjiang Province, General Secretary Xi Jinping first proposed the concept of "new quality productive forces" (Wang, 2024). In 2024, "new quality productive forces" was included in the *Report on the Work of the Government* for the first time.

"New quality productive forces" is a type of productivity dominated by new

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industries, the characteristic is innovation, the key lies in high quality, and the essence is advanced productivity (Yang & Hao, 2024; Wang, 2024; Jian & Nie, 2023; Kuai & Cui, 2024; Xu, Mu, & Li, 2024; Yu, Chen, & Zhang, 2024). It is an era proposition put forward in response to the world's scientific and technological revolution and industrial transformation. In the process of forming new quality productive forces, talent is the most dynamic and decisive subject and the decisive factor (Yu, Su, & Zhang, 2026; Yang, 2024; Wang, 2025; Hong & Bian, 2025; Du, 2025; Huang & Liu, 2024). The proposition of "new quality productive forces" pointed out the direction for the reform and development of China's higher education, and also put forward new and higher requirements for the cultivation of talents in higher education.

Curriculum and teaching are the main channel and main battlefield for cultivating talents in higher education. They should take supporting and serving the development of new quality productive forces as their primary task, actively reform and proactively adapt to the requirements of developing new quality productive forces.

Taking the course of *Physical Chemistry* as an example, the authors conducted a practical exploration of curriculum teaching reform of higher education under the background of new quality productive forces, mainly involving two aspects: first, to promote ideological and political education through the reform of "Ke-Cheng Si-Zheng"; second, to enhance the cultivation of students' autonomous learning ability, critical thinking and creativity through the inquiry-based teaching reform.

*Physical Chemistry* offered for the major of Light Chemical Engineering was selected as the reform pilot. There were 58 undergraduate students who had this course in their 3rd and 4th semesters (September to June of the following year). The course of *Physical Chemistry* covered 9 chapters of the first law of thermodynamics, the second law of thermodynamics, thermodynamics of multi-component systems, chemical equilibrium, multiphase equilibrium, electrochemistry, interface phenomenon, chemical kinetics, and colloid chemistry. "Ke-Cheng Si-Zheng" reform and inquiry-based teaching reform were introduced into all the 9 chapters.

The reform was expected to make curriculum teaching more helpful in cultivating students to be "both virtuous and talented".

## 2. Promoting Ideological and Political Education through the Reform of "Ke-Cheng Si-Zheng"

In carrying out curriculum and teaching reform, we must adhere to the original aspiration of "cultivating talents for the Party and the State", and implement the basic policy that "education must serve socialist modernization and the people, and must be combined with productive labor and social practice to cultivate socialist builders and successors who are well-rounded in morality, intelligence, physical fitness, aesthetics and labor" (Yang & Hao, 2024). Therefore, in fostering qualified talents, ideological and political education comes first. And "Ke-Cheng

Si-Zheng" reform arises at the right moment.

"Ke-Cheng" means courses, "Si-Zheng" means ideological & political education, and "Ke-Cheng Si-Zheng" means that all courses shall carry ideological & political education, and ideological & political education shall be embodied in all courses (Zhou, Guo, & Liu, 2019a; Zhou, Guo, & Liu, 2019b; Guo, Zhou, Chen, Song, & Rong, 2017). In the "Ke-Cheng Si-Zheng" reform, ideological and political education elements contained in courses shall be explored and their function of ideological and political education shall be given full play, so as to achieve a three-dimensional educational pattern, and build a comprehensive ideological and political education system that involves all personnel, the entire process, and all courses. Ideological and political education is embodied and implemented throughout the entire teaching process. "Ke-Cheng Si-Zheng" focuses on conducting ideological and political education in an implicit way, combining ideological and political education with intellectual education, and integrating ideological and political education into the imparting process of course knowledge.

The authors conducted "Ke-Cheng Si-Zheng" reform in the course of *Physical Chemistry*. Based on the imparting of course knowledge, the ideological and political education elements contained in the course were deeply explored, and their ideological and political education function was given full play. Various methods such as "thematic embedding", "highlighting the key points", and "invisible infiltration", etc. were employed to incorporate ideological and political education into the teaching practice.

Classroom teaching is the main channel for imparting knowledge and permeating ideological and political education. After-class exercises are an important channel for consolidating knowledge and inspiring thoughts. Interaction and contact are important ways to understand, influence, infect and cultivate students. The authors studied the teaching materials carefully to master the knowledge system, key points and difficulties deeply, and explored the ideological and political education elements contained therein comprehensively. The authors carefully designed after-class exercises and selected good questions that are highly scientific and thought-provoking and have educational significance. After class, the authors proactively interacted and communicated with students to understand, influence, inspire and cultivate them with correct worldviews and outlooks on life and values. The above-mentioned channels and way were fully employed so as to achieve the integration of knowledge imparting, ability cultivation, intellectual development and ideological and political education.

In the "Ke-Cheng Si-Zheng" reform, ideological and political education was mainly reflected in the following aspects: patriotism, ideals and beliefs, ecological civilization thought, socialist core values, professional quality, people-oriented thought, and excellent Chinese culture, etc.

We here take patriotism education as an example to elaborate on the specific methods and approaches of integrating ideological and political education into the course teaching.

### 2.1. Ideological and Political Education Elements ("Ke-Cheng Si-Zheng" Materials)

Science knows no borders, but scientists have their motherland. When discussing the development history of China's chemical industry, the advanced deeds of the older generation of scientists and industrialists were introduced, allowing students to understand and learn their lofty spirit and patriotic sentiments reflected in their diligent practice, selfless dedication and motherland service during the hard times. Typical examples included but not limited to the followings. Mr. Hou Debang, the founder of China's caustic soda industry, gave up the favorable conditions abroad and returned to his motherland with a sincere patriotic heart. After arduous exploration, he invented the "Hou's Caustic Soda Process", opening up a brand-new path for caustic soda technology, breaking the foreign monopoly, and bringing not only economic benefits but also high national honor to the motherland. Mr. Fan Xudong, known as the "Father of China's National Chemical Industry", was filled with patriotic feelings. He overcame numerous difficulties, worked hard to start a business, and shouldered the responsibility of developing China's national chemical industry. He made outstanding contributions to the start and development of China's national chemical industry. Mr. Wu Yunchu, with his sincere patriotic heart and indomitable entrepreneurial spirit, founded the first monosodium glutamate factory, chlor-alkali factory, acid-resistant pottery factory and factory for producing synthetic ammonia and nitric acid in China. He also sponsored outstanding students from poor families and cultivated advanced scientific and technological talents, making outstanding contributions to the rise and development of China's chemical industry.

### 2.2. Methods and Carriers for "Ke-Cheng Si-Zheng"

Teacher's classroom presentation, data search after class by students; Information-based carriers such as documentary news, pictures and videos; Ideological and political education accounts for 10 to 20% of the class hours.

### 2.3. Expected Effectiveness for "Ke-Cheng Si-Zheng" Reform in This Example

To inspire students' patriotic feelings and enhance their patriotic spirit.

## 3. Promoting the Cultivation of Autonomous Learning Ability, Critical Thinking and Creativity through Inquiry-Based Teaching Reform

Taking the course of *Physical Chemistry* as the carrier, the authors carried out the inquiry-based teaching reform. Inquiry-based teaching is a student-centered and problem-oriented teaching model, emphasizing that students construct knowledge and cultivate innovative thinking and practical abilities through active observation, analysis, conjecture, argumentation and other processes in practice. Inquiry-based teaching reform combined with curriculum reform is being tried in many institutes and courses (Rogat, Wiggins, Tan, & Olenloa, 2026; Duan, Qi, & Zhu, 2026; Kumazah & Agyei, 2026; Ganajová, Orosová, Sotáková, & Letošníková, 2025; Pili, Bulanon, & Fajardo, 2026; Alison, Harrison, & Tatiana, 2025; Ding, 2026; Wang, Ma, Qiu, Xie, Zhao, & Chen, 2023).

The teaching and learning were set in reasonable problem/question situation to inspire students to learn the course knowledge hidden behind the problems/questions through analyzing and solving them, so as to enhance students' dominant position in learning, mobilize and give full play to their subjective initiative, and transform passive learning into active learning (Zhou & Guo, 2021). The rigid concept in traditional teaching that "teachers are responsible for lecturing and students for listening" was changed, and the one-way monotonous relationship of "I speak—you listen" between teachers and students was transformed into a two-way cooperative relationship of "lecturing and learning, exploration and feedback".

The knowledge points to be learned were listed before class and problems/questions were reasonably set. The problems/questions should well reflect the knowledge points to be learned, be based on the textbook but appropriately exceed it, be open, genuine, and have a certain degree of complexity. They should also be interesting and have an application background.

Students were required to analyze the problems/questions in after-class time, sort out what curriculum knowledge is needed to solve the problems/questions, consult materials and extract key information, explore the intrinsic connection between the problem/questions and curriculum knowledge, obtain solutions to the problems/questions, and think about how to expand the application of knowledge, etc. Inspired by the problems/questions, students would actively analyze and sort out the curriculum knowledge involved, take the initiative to explore, and come up with certain solutions to the problems/questions. In classroom, students would listen purposefully to the teacher's explanation of knowledge points and analysis of problems/questions, comparing their own solutions with the teacher's. They would cooperate with the teacher and classmates to discuss and explore the curriculum knowledge behind the problems/questions, draw inferences by analogy, and master the curriculum knowledge contained therein rationally and thoroughly. In this way, the ability to analyze and solve problems/questions would be cultivated, and the habit of autonomous learning would be formed, and critical thinking and creativity would be developed.

Taking the teaching and learning of the liquid-solid equilibrium phase diagram of a two-component condensation system that generates an unstable compound as an example, the implementation path of teaching reform is expounded here.

### 3.1. Autonomous Learning of the Basic Knowledge Points

One week before the scheduled classroom teaching about "the liquid-solid equilibrium phase diagram of a two-component condensation system that generates an unstable compound", the following problems/questions were allocated. As shown in **Figure 1**, components A and B generate the unstable compound C. Now we want to prepare a certain amount of C, please design the preparation process. Students were encouraged to use AI tools for autonomous learning.

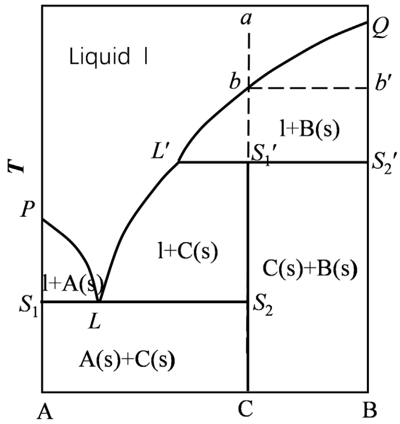


**Figure 1.** Liquid-solid equilibrium phase diagram of two-component system with one unstable compound formed.

Students used AI tools (Doubao, DeepSeek, ChatGPT, PyTorch、Jupyter Notebook, Coursera, StudyBlue, etc.) and textbooks to acquire relevant knowledge about this phase diagram. The autonomous learning reports submitted by students online were almost the same, showing that the outputs from different AI tools and textbooks were basically the same, which can be summarized as follows.

The simplest system for generating unstable compounds is that when two components A and B only produce one unstable compound C, and both C and A, as well as C and B, are completely immiscible in solid state. When solid compound C is heated, the system point moves vertically upward from C. When the temperature corresponding to the $S_1'$ point is reached, C decomposes into solid compound B and molten liquid. The solid phase point is at $S_2'$, and the liquid phase point is at $L'$. At this temperature, three phases are in equilibrium with no degree of freedom, and the system temperature and the composition of each phase remain unchanged. The temperature begins to rise only after C has completely decomposed. And then if the heating continues, B will constantly melt into the molten liquid, increasing the content of B in the liquid. The liquid phase point will move along $L'b$, and the solid phase point will move along $S_2' b'$. The system has one degree of freedom. When the system point reaches point *b*, all B melts completely and disappears. Point *b* is the liquid phase point, and the composition of this liquid is the same as that of the original compound C. The next step is the heating process of the liquid phase from system point *b* to *a*. The phase transition process of the sample at system point *a* in a cooling way is exactly the opposite of that of the compound C analyzed above in a heating way.

### 3.2. The Preparation Process for Compound C

Based on the knowledge about the phase diagram acquired through autonomous learning, about 60 % of the students came up with the same preparation method:

according to the composition of C, thoroughly mix the two components A and B, heat and melt them to a certain temperature above point *b*, and then cool them to the temperature corresponding to or below the $L'$ - $S_1'$ - $S_2'$ three-phase line. In this way, pure compound C could be obtained. When asked why, they firmly believe that "The phase transition process of the sample at system point *a* in a cooling way is exactly the opposite of that of the compound C analyzed above in a heating way."

40% of the students thought that thing was not as simple as above mentioned, but they could not propose a clear a plan. Their desire of knowledge was arosed, and the opportunity for classroom teaching and discussion had come.

As for the plan for preparing compound C designed by the 60% of students, from a scientific or thermodynamic perspective, there is no problem. However, in actual engineering or production, pure compound C cannot be obtained in that way; instead, a mixture of C, B and A will be produced. The crux of the problem lies in the fact that no critical thinking has been inspired and no creativity has been stimulated.

Textbooks or AI tools provide fixed and fundamental knowledge points. For instance, what is presented here is the multiphase equilibrium in thermodynamics, but the time factor in dynamics is not taken into account, nor is the practical engineering factor considered.

According to the plan proposed by the students through autonomous learning, the actual phase transition process is as follows. When the system cools down to point *b*, solid B begins to precipitate from the liquid phase, corresponding to the solid phase point $b'$. With temperature continuing to drop, solid phase B keeps precipitating, the liquid phase point moves along $bL'$, and the solid phase point moves along $b'$ $S_2'$. When the system point reaches $S_1'$, liquid $L'$ and solid B start to react in a certain proportion to form compound C. But it is not the case that liquid $L'$ and solid B react completely to form pure compound C. In that way, only thermodynamic factors were taken into account, and the reaction time can be infinitely long. But in actual engineering or production, dynamic factors must also be taken into account, and the reaction time is not infinitely long. Solid B is immersed in liquid $L'$, and the reaction between them two takes place on the surface of solid B. The compound C generated here also covers the surface of solid B. When C covers to a certain thickness, it hinders further contact and reaction between liquid $L'$ and solid B under the cover of solid C. At this point, the reaction between liquid $L'$ and solid B for forming compound C has actually stopped, and what is presented is a "boiling dumpling" state with B as the "filling", C as the "wrapper", and liquid $L'$ as the soup. Solid B is encapsulated into a shell made of solid C, and no longer takes part in the reaction. It is equivalent to that solid B is removed from the system and is no longer regarded as a phase in the equilibrium system. This is called "peritectic phenomenon". At this point, the system is composed of molten liquid $L'$ and solid phase C, returns to one degree of freedom, and the temperature can continue to drop. Liquid phase point moves along $L'L$, and compound C precipitates simultaneously. At this time, the precipitated compound C can continuously cover on the surface of the "dumpling" or form a new "solid dough" that is composed solely of C. When cooled to the temperature corresponding to point *L*, the liquid simultaneously saturates A and C, and solid phases A and C precipitate simultaneously until the last droplet of *L* disappears. The final product is a mechanical mixture of solid phases A, B and C, existing in forms such as "dumplings" and "solid doughes".

After the teacher's explanation, the students suddenly understood and their understanding of the knowledge point of multiphase equilibrium gets deepened. How should A and B be proportioned and how should the cooling process be controlled to prepare pure compound C? The answer was proposed collectively by the students and teacher after lively discussion: Mix A and B to ensure that the overall composition, that is, the system point, is between point *L* and point $L'$ horizontally, for example, the system point is located at *e*; heat and melt the mixture to reach point *c*, then cool it down; at point *d*, compound C begins to precipitate, and the liquid phase point moves along the *dL* line. When the temperature approaches that corresponding to point *L*, that is, the system point approaches point *e* (note that it is "approach", but not "reach", otherwise solid phase A will precipitate), stop cooling. At this time, the solid phase "fished out" from the system is pure solid compound C.

## 3.3. Advanced Problem/Question 1

After the solid compound C is "fished out", the residual liquid phase near point *L* no longer has the ability to generate pure C. How can the output rate of C be increased? Students were inspired to use the "lever rule". The answer given collectively by the students and teacher after lively discussion is that the initial ratio of A and B should make the system point closer to point $L'$ horizontally as much as possible.

## 3.4. Advanced Problem/Question 2

Suppose the system points *L*, $L'$ and C are located horizontally at 0.2, 0.4, 0.6. How can we obtain 500 grams of pure C in the most economical way (suppose that: cost only takes raw materials into account, the unit prices of A and B are the same, the residual liquid at point *L* has no value at all)? The answer was proposed collectively by the students and teacher after lively discussion: 600 grams of A and 400 grams of B are mixed to prepare C, 500 grams of C is "fished out", and 500 grams of molten liquid close to the point *L* is left.

## 3.5. Advanced Problem/Question 3

Now if 3000 grams of C need to be prepared, what is the most economical way? The answer was proposed collectively by the students and teacher after lively discussion: further add 500 grams of mixture of A and B (in accordance with the composition ratio of C: 200 grams of A and 300 grams of B) into the above 500 grams residual liquid close to point $L$ in Problem/Question2, heat it up over point $L'$, then cool it down to generate pure C, "fish out" 500 grams of C. Repeat this previous operation for 5 times. The final result is that a total of 3500 grams of raw materials of A and B are used, 3000 grams of pure compound C are obtained, and only 500 grams of liquid phase close to point $L$ are left as waste.

### 3.6. Advanced Problem/Question 4

Can't 3000 grams of C be prepared in one go? The answer was proposed collectively by the students and teacher after lively discussion: Yes, of course. 3000 grams of C can be prepared in one go. But the cost is that more raw materials will be wasted. The result is that 3000 grams of C are produced while 3000 grams of liquid phase close to point $L$ will be left to be wasted instead of 500 grams.

## 4. Evaluation of Reform Effectiveness

### 4.1. About "Ke-Cheng Si-Zheng"

The ultimate goal of education is to cultivate virtue and foster talent. The manifestation of teaching effect of ideological and political education is very complex, featuring both explicit and implicit effects, both direct and indirect effects, and both short-term effects and long-term effects. Therefore, the evaluation of the teaching effect of ideological and political education is a complex project and cannot be fully reflected by simple bar and box tables. As a new thing, there is also no ready-made and simple method to evaluate the effect of "Ke-Cheng Si-Zheng" reform.

During the implementation of the reform, the members of the research team carefully observed the students' reactions, conducting observations and analyses from aspects such as their enthusiasm for learning, classroom performance, mental outlook, and behavior. At appropriate times, we also examined the reform effects through methods such as student interviews, questionnaires, and group discussions. The investigation revealed that students' response to the "Ke-Cheng Si-Zheng" reform in the course was positive and affirmative. They were more likely to accept this permeating and subtle educational approach. They identified with and approved of the patriotism, ideals and beliefs, ecological civilization thought, socialist core values, professional quality, people-oriented thought, and excellent Chinese culture that we advocated. The enthusiasm and initiative in learning professional knowledge and skills of the course have also increased. The results showed that "Ke-Cheng Si-Zheng" reform is feasible and effective.

### 4.2. About Inquiry-Based Teaching Reform

The inquiry-based teaching reform has effectively promoted students' learning of course knowledge and the cultivation of autonomous learning ability, critical thinking and creativity. *Physical Chemistry* is a rather difficult course, and many students dislike it. The inquiry-based teaching reform has significantly increased students' enthusiasm for learning *Physical Chemistry*. The increase of classroom attendance rate and the frequency of asking questions and discussing issues concerning *Physical Chemistry* proved it. And the average score in final exam of *Physical Chemistry* of this year's students (involved in the reform) increased by 12% compared with the previous year's students (not involved in the reform), fully proving the promotion of students' learning of course knowledge.

Each chapter has contents that students need to learn independently outside of classroom lectures, for example, dissolution enthalpy, dilution enthalpy, the standard molar enthalpy of formation of ions, the first law of thermodynamics for steady flow processes in the chapter of the First Law of Thermodynamics; the principle of distillation, graphical representation of a three-component system, thermodynamic characteristics of the second-order phase transition in the chapter of multiphase equilibrium. The completion rate of above-mentioned self-study contents was as high as 86% for this year's students compared with that of about 60% for the previous year's students, fully proving the cultivation of autonomous learning ability. The students' repeated revisions to the innovative programs assigned by the teacher reflected their critical thinking. The quantity and quality of students' independently designed innovative programs reflected their innovative ability. 6 independently designed innovative programs from this year's students were successfully shortlisted in the university-level and state-level innovative programs for college students compared with that only 2 independently designed innovative programs from previous year's students were shortlisted in the university-level and state-level innovative programs for college students. All these proved that the inquiry-based teaching reform has effectively promoted the cultivation of autonomous learning ability, critical thinking and creativity.

## 5. Conclusion

"Ke-Cheng Si-Zheng" reform has effectively promoted ideological and political education in an implicit way, and the inquiry-based teaching and learning reform has effectively enhanced the cultivation of students' autonomous learning ability, critical thinking and creativity. The synergistic coupling of the two reforms makes curriculum teaching more helpful in cultivating students to be "both virtuous and talented". Under the background of new quality productive forces, the reform of higher education including curriculum teaching reform is imperative. The work in this paper may have certain leading and exemplary significance.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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