# Exploration of Teaching Reform of Basic Chemistry in Higher Vocational Education Based on STEAM Education Concept

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**Abstract** With the proposal of the National Vocational Education Reform Plan, vocational colleges tend to cultivate students' hands-on ability, problem-solving ability, and innovation ability. The core of STEAM philosophy lies in utilizing science, technology, engineering, art, and mathematics to comprehensively cultivate students, addressing disciplinary differences and emphasizing the cultivation of aesthetic education for students. This article introduces this model into the teaching of "Basic Chemistry" in vocational colleges, comprehensively cultivating students' abilities and achieving good progress.

**Keywords** Vocational Education; STEAM Education; Curriculum Design

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## Introduction

With the development of China's economy and the transformation of society, the reform of higher vocational education in China is constantly underway, and basic chemistry, as a fundamental compulsory course in chemical engineering, pharmacy, medicine and other disciplines, is also constantly being reformed. The Third Plenary Session of the 20th Central Committee of the Communist Party of China emphasized the coordinated promotion of the integrated reform of the education, science and technology, talent system and mechanism, put forward the goal of accelerating the construction of a high-quality education system, and called for optimizing the layout of higher education and promoting the reform of universities in a classified manner. Our exploration of new paths in vocational education is not only a profound reflection, transformation, and reconstruction of traditional education models, but also a practical response to the metaphysical thinking of technological rationality and the essence of education. This requires us to deeply explore the internal logic of vocational education and the comprehensive development of individuals, as well as the deep integration of knowledge innovation and vocational skills. In the rapidly developing new trend of manufacturing industry, we need to open a new vocational education beacon that can not only inherit the essence of education and teaching, but also lead future development trends.

## Current Situation of Vocational Education

The main issues in vocational education are reflected in the following aspects: firstly, the problem of student sources. Most of the students who enter vocational colleges in China are those who have failed the college entrance examination, had poor study habits, and had inaccurate self-positioning; Secondly, there is a problem with teaching methods. Most schools still adopt traditional lecture based subject based teaching, which makes it difficult for students to extract the knowledge they have learned and solve practical problems in their subsequent work; Thirdly, there are differences between the skills cultivated by schools and the requirements of enterprises. In summary, the main problem that needs to be solved is to improve students' learning initiative and interest, and to pay attention to the acquisition of students' hands-on abilities.

## Case Study - Mini Sewage Treatment System

This teaching will be conducted at Chongqing Vocational College of Chemical Technology, which is a vocational college with different student sources and foundations. However, based on the usual class situation, the students have strong collaborative abilities. Having a sense of self-directed learning and possessing these abilities is the guarantee for students to study STEM courses. The analysis of students' learning characteristics during learning is shown in Table 3-1:

Table 3-1. Analysis of Learner Characteristics.

| Project | Content |
|---|---|
| Analysis of Students' Learning Ability | Freshman students have initially developed the abilities of cooperative learning, self-directed learning, and inquiry-based learning |
| Analysis of Students' Learning Styles | Depending on the specific situation, experiments and other activities may have a certain appeal to students |
| Analysis of Age Characteristics of Students | Freshman students are between the ages of 18-19, and through previous studies, their cognition tends to mature. The continuous accumulation of life experience also provides a lot of help for learning |
| Analysis of Students' Learning Attitudes | Students have a certain accumulation of knowledge in chemistry courses, but their foundation is poor. Therefore, the focus should be on cultivating students' interest and scientific literacy in learning chemistry. Based on the characteristics of chemistry, attention should be paid to linking real-life problems in the teaching process, and more opportunities should be created for students to personally conduct experiments, allowing them to experience the unique charm of chemistry experiments |
| Analysis of Students' Existing Knowledge and Experience | Prior to this, students had already acquired some practical knowledge such as filtering in their daily lives. In middle school, I learned about water resources in China, and in biology, I learned the basic knowledge of bacteria. However, students do not know much about the selection of filter materials, which can be explored by students |
| Group students into groups | According to feature analysis and investigation of students' learning situation, students are grouped into four groups with different responsibilities: one person is responsible for document recording, two people are responsible for experimental operations, and one person is responsible for problem defense. Let's work together to complete the design and other related parts |

The students we are facing this semester are majoring in environmental monitoring, and sewage treatment is a necessary subject to master. In daily life, we often see situations where water is polluted. So, how can we prevent pollution and purify polluted water into household water? This is the focus of this course. This lesson is divided into two parts. The first part introduces the classification of water pollution, analyzes the causes of water pollution, explores methods of water purification, and designs the process of making a homemade water purifier. In the second lesson, students will create a simple sewage treatment device based on their own design drawings, and finally explain to them the working principles of some household water purification treatment devices. The teaching content of this lesson is based on real scenarios of water pollution in daily life. During the learning process, students explore solutions, design sewage treatment systems, and experiment with their own designs to see if their solutions are feasible. This appropriately integrates STEAM education into this chemistry class. As shown in Table 3-2:

Table 3-2. Teaching Objectives of Mini Sewage Treatment System.

| project | | content |
|---|---|---|
| Teach Learn Order Mark | science | 1. Familiar with the classification of environmental pollution.<br>2. Understand common methods for purifying water, such as adsorption, precipitation, filtration, and distillation.<br>3. Explore the water filtration capacity of different materials. |
| | technology | 1. Learn to use funnels, beakers, and other devices for filtration<br>2. Test the water purification effect of activated carbon and alum |
| | engineering | 1. Complete the design and assembly of the filtration system.<br>2. Improve the filtration process. |
| | mathematics | The relationship between different filter media and filtration speed |
| Teaching Key and Difficult Points | a key | Understand the methods of water purification and simple identification methods for hard and soft water |
| | difficulty | Understand the principles of filtration and evaporation |

## Teaching Design and Development

Under the guidance of teaching analysis, this teaching design has set task lines, which correspond to the problems that need to be solved when completing tasks and acquire knowledge while completing tasks to solve problems. The teacher provides specific teaching scenarios, in which the teacher acts as a guide and the students are the main body of the classroom. Through group cooperation, learning is carried out, and STEAM education related knowledge is applied to solve problems that arise in the teaching scenario, ultimately obtaining knowledge.

This teaching design mainly includes four learning tasks, namely: understanding water pollution, exploring methods of water purification, designing a simple sewage treatment device, and making a self-made simple sewage treatment device. Based on these tasks, corresponding questions are set for each task. According to the design concept of the mini sewage treatment system, this project is divided into two lessons and seven stages. This course is designed for students with chemistry as the main subject and physics, biology, mathematics, and other related knowledge as supplementary subjects. Enable students to engage in learning in real-life scenarios, solve problems encountered, and acquire corresponding knowledge and skills during the engineering design process. The specific teaching flowchart is shown in Figure 3-3:

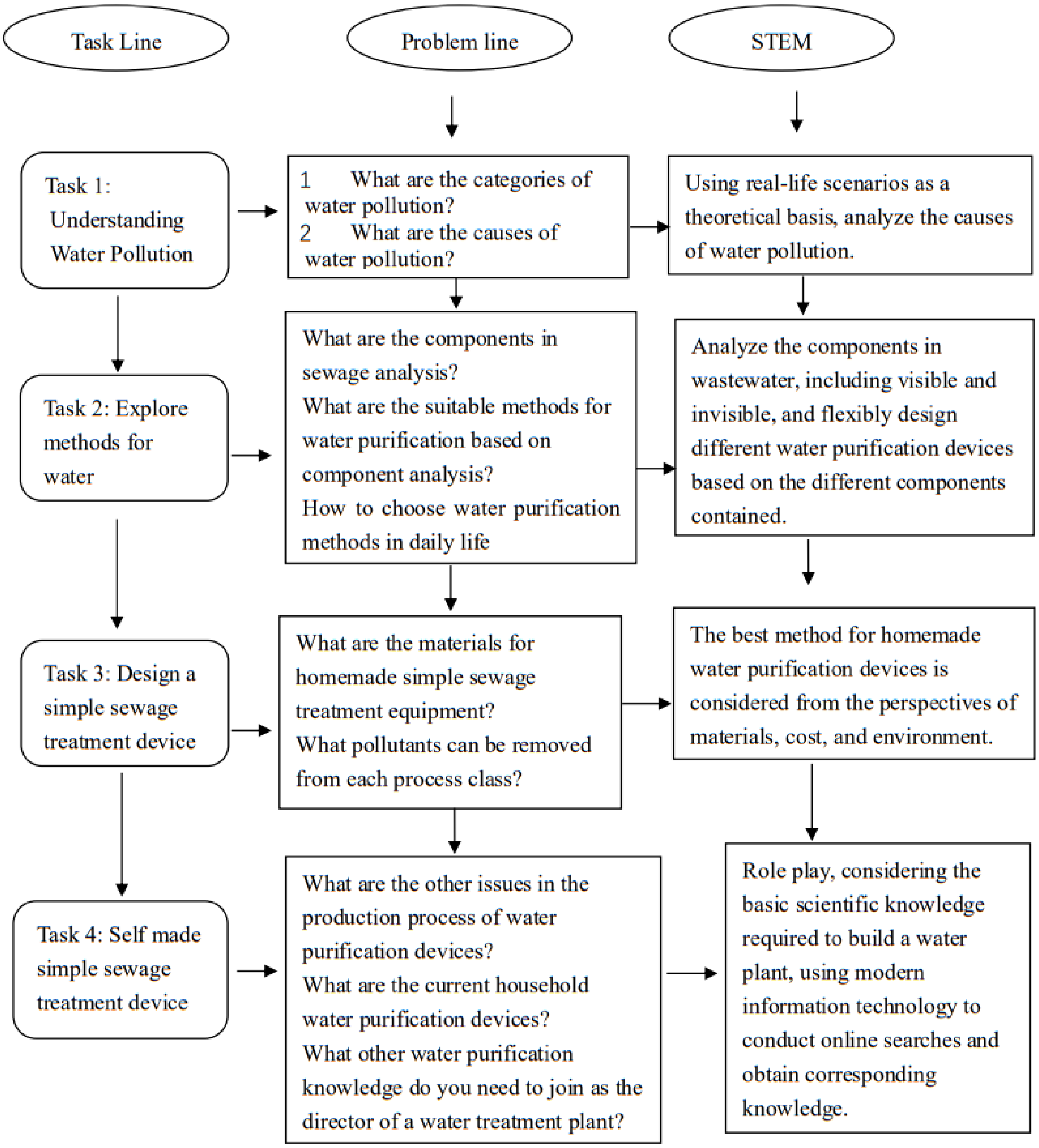

Figure 3-1. Design Ideas for Mini Sewage Treatment System.

## Evaluation method

To investigate the impact of STEM teaching mode on students, the teacher evaluated each group according to the Teacher Evaluation Scale 4-3 after each course implementation. The whole class was divided into 12 groups, and the teacher filled out 12 questionnaires each time. The statistical analysis results of the first level indicator data in evaluation scale 4-3 are shown in Table 4-6. The first level indicator data is the sum of the three second level indicators included in it, with a maximum score of 12 points for each item. The statistical analysis results of the secondary indicators in evaluation scale 4-3 are shown in Table 4-7, with a maximum score of 4 points for each secondary indicator.

Table 4-1. Statistical average score of first level indicators for two course teacher evaluation scales.

| First level indicator | The first course | End of semester courses | disparity | Growth rate% |
|---|---|---|---|---|
| Teamwork ability | six point eight three | eight point seven five | one point nine two | twenty-eight point one one |
| Information expression ability | six point five eight | seven point six seven | one point zero nine | sixteen point five seven |
| Project operation capability | six point one seven | seven point three three | one point one six | eighteen point eight zero |

From the above table, it can be seen that students have relatively weak project operation abilities during the course learning process. After the course learning, their project operation abilities have improved, but they still need to continue to pay attention. From the comparison of the average scores of the two courses before and after, through STEM education, students' abilities have been improved to a certain extent.

Table 4-2. Statistical average score of secondary indicators for two course teacher evaluation scales.

| SECONDARY INDICATORS | THE FIRST COURSE | END OF SEMESTER COURSES | DISPARITY | GROWTH RATE% |
|---|---|---|---|---|
| Cooperative consciousness | two point four two | three point two five | zero point eight three | thirty-four point two nine |
| Spirit of cooperation | two point three three | three point zero eight | zero point seven five | thirty-two point one nine |
| Collaboration skills | two point zero eight | two point nine two | zero point eight four | forty point three eight |
| Verbal expression | two point three three | three point zero eight | zero point seven five | thirty-two point one nine |
| Text expression | two point zero eight | two point eight three | zero point seven five | thirty-six point zero six |
| Practical expression | two point one seven | two point four two | zero point two five | eleven point five two |
| Project Design | two point zero eight | two point five eight | zero point five zero | twenty-four point zero four |
| Project completion rate | two point one seven | two point three three | zero point one five | six point nine one |
| Result analysis | one point nine two | two point four two | zero point five zero | twenty-six point zero four |

According to Table 4-2, create a chart where A represents cooperative awareness, B represents cooperative spirit, C represents cooperative skills, D represents language expression, E represents written expression, F represents practical expression, G represents project design, H represents project completion, and I represents result analysis. The statistical chart is shown in Figure 4-1.

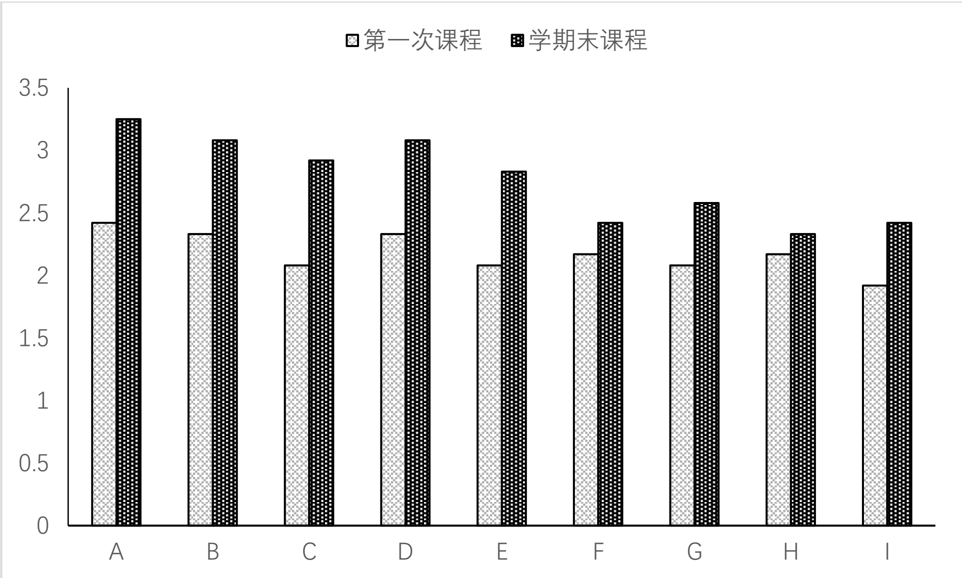

Figure 4-1. Average score of secondary indicators in the two course teacher evaluation scales.

According to Figure 4-1 and Table 4-2, after integrating STEM education into the chemistry classroom, various abilities have been improved in all aspects compared to the first course after completing the last course. Among them, project design and project completion in project operation ability are relatively weak areas for students, and they need to continue to work hard to improve. Collaboration skills have also been greatly improved. Based on the comprehensive data, it can be concluded that students have improved their teamwork, information expression, project design, and other aspects after participating in high school chemistry courses under the STEM education concept.

After completing each complete topic, students filled out a student self-assessment scale and evaluated it based on the student self-assessment scale 4-4. There was a total of 48 students in the class, and 48 self-assessment scales were distributed each time. 48 of them were collected, with a recovery rate of 100%. The specific data statistics are shown in Table 4-3:

Table 4-3. Average scores of self-assessment scales for two courses by students.

| Evaluation Content | The first course | End of semester courses | disparity | Growth rate% |
|---|---|---|---|---|
| Mastery of theoretical knowledge | two point two three | two point nine four | zero point seven one | thirty-one point eight three |
| The resolution of problems encountered in the course | one point nine eight | two point seven seven | zero point seven nine | thirty-nine point nine zero |
| Project design status | one point eight nine | two point six nine | zero point eight zero | forty-two point three three |
| Collaboration with classmates in the group | two point one one | two point eight one | zero point seven zero | thirty-three point one eight |
| Project completion status | two point one two | two point nine six | zero point eight four | thirty-nine point six two |
| Language expression during reporting | two point zero four | two point eight seven | zero point eight three | forty point six seven |

According to Table 4-3 for chart analysis, A represents the mastery of theoretical knowledge, B represents the resolution of problems encountered in the course, C represents the project design, D represents the cooperation with group classmates, E represents the completion of the project, and F represents the expression of language when reporting. The statistical chart is shown in Figure 4-2:

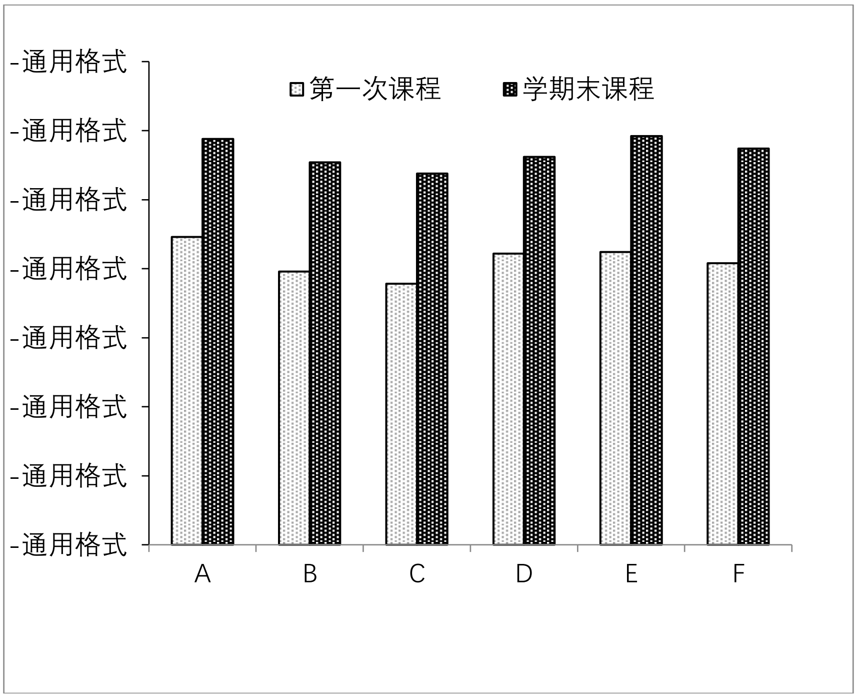


Figure 4-2. Average Score of Student Self Evaluation Scale for Two Courses.

According to Table 4-3 and Figure 4-2, most students believe that integrating STEM education into middle school teaching has helped improve their various abilities. From the statistical data, students have the weakest abilities in project design and problem-solving after the first course, which is closely related to their previous learning experience. After learning STEM courses, their project design and problem-solving abilities have improved to some extent. It is gratifying that the cooperation between students and group members is becoming more and more tacit, and the participation in the project is increasing. Students can truly participate in the learning of the entire course and enjoy it.

## Conclusion

This study conducted in-depth research on STAEM education through literature review, and integrated STEM education into the teaching of Basic Chemistry in vocational colleges. Based on the training plan and curriculum standards of the Environmental Monitoring Technology major, combined with the curriculum standards of STEAM education, the teaching objectives are set in five aspects: science, technology, engineering, art, and mathematics; Constructing a teaching mode that differs from general inquiry based teaching, the curriculum design runs through the entire classroom with problem lines and task lines, aiming to use this teaching method to drive students' learning enthusiasm and truly do a good job in student-centered teaching.

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