RESEARCH ON TEACHING REFORM OF PETROCHEMICAL COURSES IN UNIVERSITIES IN THE CONTEXT OF CARBON NEUTRALITY

Junchao Zhao*

Faculty of Teacher Education, Hechi University, Hechi, Guangxi, 546300, China

qq1987472022@163.com

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ABSTRACT

The increasing pollution caused by carbon emissions has led to a growing call for emission reduction. With China's current goal of carbon neutrality, how to innovate the petrochemical industry has become a hot issue. As a higher education institution that delivers talent for the petrochemical industry, it is in line with this trend to carry out teaching reforms of professional courses. In this paper, we collect data extensively for the evaluation of course attainment in the petrochemical industry and carry out the weight allocation of factors. Two classes of a university's 2018 class of petrochemical industry majors were used as the comparison objects. One of the classes was taught in a reformed manner while the other class was taught in a traditional manner. The results showed that the overall score of the class subjected to reformed instruction was 78.9, which was greater than the 74.6 score of the class taught using the traditional approach. In addition, when surveyed for feedback on course content, it was found that a whopping 92% of students showed identification with their major. Only 2% of the students felt that the new teaching style was a waste of their time.

KEYWORDS

Carbon neutrality; petrochemical industry; professional courses; teaching reform; higher education institutions.

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1. INTRODUCTION

With today's goal of carbon neutrality, how to harmonize petrochemicals and ecology has become a hot issue that needs to be addressed urgently [1-3]. The goal of achieving carbon neutrality by 2060 was first proposed by Chinese President Xi Jinping at the United Nations General Assembly on September 22, 2020. The introduction of this target not only shows China's great power role but also brings opportunities and challenges for the transformation and upgrading of China's petrochemical industry. In this context, how to use the carbon neutrality target to force oneself to reduce carbon awareness is something that should be taken seriously by the industry [4-6]. Actively developing energy-saving and low-carbon processes and participating in the construction of a carbon emission trading market are important means to achieve carbon neutrality [7-9]. As a higher education institution providing talents for the petrochemical industry, how to adapt teaching to the new environment is also one of the means to accelerate the achievement of carbon neutrality [10,11]. In the new era, social development and economic construction need suitable talents. At present, all universities are in full swing to cultivate new engineering technical talents. As a pillar industry of the national economy, petrochemical products cover a wide area and are closely related to people's life [12-14]. The corresponding teaching reform for it should not only take into account the complexity of its knowledge system but also the changes of industry standards brought by the reform. As a long chain of industries, the huge impact of drastic changes is unforeseeable. Various reasons make the corresponding pedagogical reform difficult, and the small number of reference examples leads to no standards to follow.

Amin M S [15] studied the impact of providing students with appropriate carbon reduction materials and presenting scientific explanations to a new generation of students. Gamarra A R [16] conducted an in-depth assessment of how well five public schools were performing in their school environments as they transitioned to a low-carbon economy and a sustainable social model. Du J [17] investigated the effectiveness of a psychosocial approach to teaching and learning to foster carbon reduction behaviors such as energy conservation in dormitories. A questionnaire survey of 290 students was conducted and found that this approach was effective in increasing the body of knowledge about energy-saving behaviors. Students were able to better understand energy use behaviors by identifying the role of ethical beliefs. Mazhar M [18] explored the barriers encountered in carbon management in UK universities and highlighted the main challenges that need to be addressed. In his study, a mixed-method approach was used to conduct a content analysis of carbon management approaches, which led to the exploration of barriers. These barriers can help to establish some theoretical support for carbon emissions. Sippel M [19] explored the lifestyle characteristics of campus students at a time when universities are taking on increasing responsibility for climate protection. After collecting data on students' lifestyles and emission patterns through questionnaires, a web-based carbon calculator was used to perform calculations. An attempt was made to identify appropriate ways of living with low carbon emissions on campus. Udas E [20] in his

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study shared an institutional process aimed at a gradual transition towards carbon neutrality. In order to achieve the goal of carbon neutrality, he argues that three major transformational strategies are adopted: carbon reduction, carbon offsetting, and mainstreaming of sustainable actions through teaching and research can be done. He has successfully developed a locally adapted sustainability institutional framework to facilitate change in day-to-day operations. Also implementing interdisciplinary research, integrating sustainability into teaching and education, and strengthening outreach programs. From the studies of various scholars above, it is easy to see that as the concept of carbon neutrality takes hold, more and more scholars are happy to combine it with pedagogical reform [21,22]. This combination will allow the concept of carbon reduction to be ingrained in students and later applied in the fields they are subordinated to. This is of great help to achieve the goal of carbon reduction.

In order to adapt to social development as well as the needs in the context of carbon neutrality, it is necessary to reform the teaching of current university petrochemical courses according to the needs. The study of the original teaching form and connotation will help to specify how to make linked adjustments and reforms to the petrochemical industry [23-25]. In addition, the construction of a new curriculum and teaching system should be oriented to the needs of society and the core of students' competence development. Universities not only have a supporting role in today's economic development and industrial transformation and upgrading but also are of great help to the cultivation of new talents and the construction of new teaching theories. This paper analyzes the teaching evaluation system based on the OBE (Outcome-Based Education) concept and applies it to petrochemical students in a university for example analysis. We try to explore whether we can cultivate high-quality petrochemical industry talents in the new situation under the new reform teaching.

2. REFORM OF PETROCHEMICAL EDUCATION IN THE CONTEXT OF CARBON NEUTRALITY

Petrochemical technology is one of the typical focuses of traditional energy engineering majors, mainly concentrating on drilling and completion engineering, subsurface fluid flow laws, development technology theory, process technology, and oil and gas reservoir management. Under the current carbon-neutral background, the reform of petrochemical technology education and teaching is an important way to achieve the goal of high-quality carbon neutrality. Specific reform ideas mainly include the following aspects.

2.1. TRAINING OBJECTIVES AND CURRICULUM

With the goal of carbon-neutral-oriented education, students are motivated and interested in carbon-neutral related industries according to their professional development needs. Understanding the close relationship between carbon neutrality

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and the oil and gas industry will enable students to better participate in engineering design and production construction in the petroleum engineering field after graduation. In addition, students can be involved in the design of strategic requirements for "decarbonization" goals in the oil and gas sector, and then engage in carbon neutral management and research and development [26,27].

To do this, it is necessary to optimize the existing teaching programs. In petrochemical technology, on the one hand, carbon capture is achieved through various measures such as carbon storage in abandoned oil and gas reservoirs and CO2 oil drives. On the other hand, carbon substitution is achieved by replacing conventional oil and gas resources with unconventional resources (shale oil and gas, geothermal energy, natural gas hydrates, etc.). Finally, the clean utilization of energy is achieved and the conversion rate is improved [28,29]. On this basis, in terms of curriculum, the traditional petroleum engineering-related courses should be retained, and appropriate elective courses on clean energy such as "carbon capture and storage" and "energy conservation and emission reduction" should be added. At the same time, courses on geothermal energy, natural gas hydrate, and hydrogen production should be introduced. The professional curriculum of the old and new teaching modes is shown in Figure 1. In the teaching process, we should focus on cultivating students' interdisciplinary awareness and establishing the concept of green, low-carbon, and clean energy, so as to lay the foundation for the carbon-neutral industry after graduation.

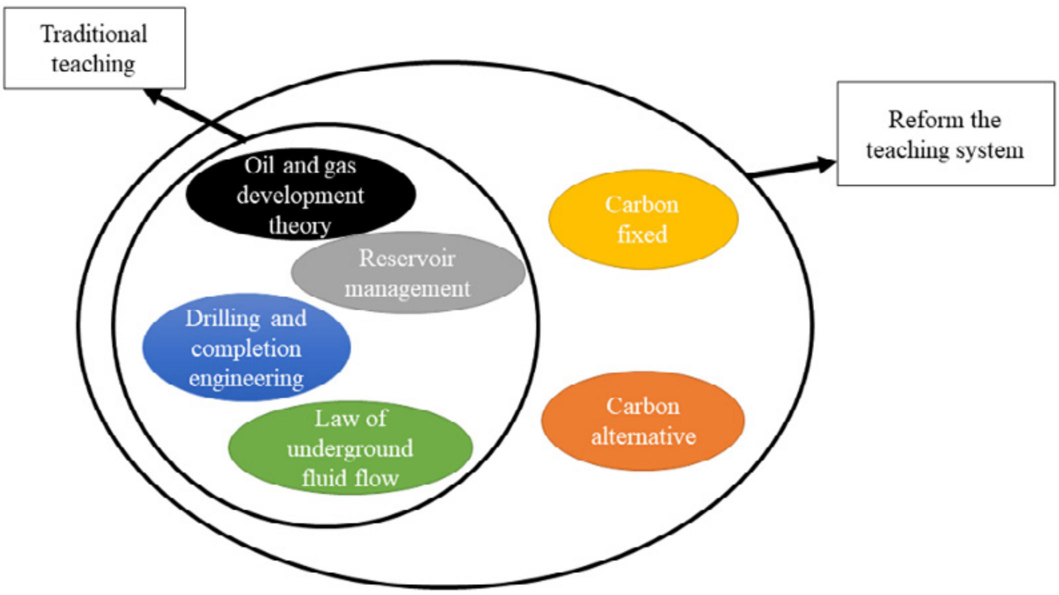

Figure 1. The curriculum of the petrochemical industry in the context of carbon neutrality

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2.2. COURSE IDEOLOGY AND TEACHING CONTENT

Using mobile devices for online teaching is an important measure to improve teaching effectiveness. From the perspective of teaching, we should make full use of online teaching resources and pay attention to the diversity of teaching methods. We should make good use of online teaching resources, shared classrooms, and other high-quality online teaching tools, pay attention to the guidance and inspiration of students' ideas, let students actively participate in classroom teaching, and improve their active learning ability and learning efficiency [30,31]. In addition, classroom teaching should also cultivate students' patriotic emotions through various typical examples, focus on the organic combination of course teaching and ideological and political education, and strengthen ideological and political leadership. The synergistic effect is brought into play to cultivate students' ideals and beliefs, moral sentiments, and other good moral qualities.

With the development of modern technology, interdisciplinarity is becoming increasingly important. Interdisciplinarity is the way to achieve the goal of high-quality carbon neutrality [32,33]. By thinking laterally, it helps to effectively solve industrial bottlenecks and promote technological development. In addition to relevant basic theories and basic skills, petrochemical students should be able to think in the cross direction of chemistry, physics, mechanics, materials, and other disciplines, and apply their knowledge flexibly to achieve the goal of carbon removal.

3. EVALUATION ANALYSIS OF THE DEGREE OF ACHIEVEMENT OF PETROCHEMICAL PROFESSIONAL COURSES

3.1. TEACHING EVALUATION SYSTEM BASED ON THE OBE CONCEPT

Curriculum evaluation is one of the important links of the modern teaching system, which plays a pivotal role in the development and improvement of teaching. A scientific and reasonable curriculum evaluation method can optimize teaching management science, promote the improvement of teaching quality and efficiency, and ensure the effectiveness of the curriculum system. In the teaching system pointed by OBE, course evaluation is one of the most basic closed-loop quality evaluations, and also an important dimension in building the teaching quality control system of universities.

The course evaluation based on the OBE concept can be summarized into three main points. The first point is to clarify the relationship between the professional training objectives, graduation requirements, and the curriculum system. The determination of course objectives must meet the students' skill development requirements in the graduation requirements. The establishment of the curriculum

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system must cover all index points of graduation requirements and establish a close connection between courses and curriculum. The teaching and learning process is based on the course objectives, and deriving the course evaluation results will allow us to accurately track course attainment as well as graduation requirement attainment, ultimately creating a closed-loop, results-oriented assessment system. The second point is to reflect the degree of course completion through course grade evaluation, reduce the weight of final exam results in course evaluation, and increase the weight of teaching process evaluation. Add various evaluation items to the teaching process evaluation, including students' daily assignments, classroom exams, learning performance, and emotional attitude. As the main body of course learning, students need to pay attention to their emotions, which can help to adjust students' learning status in time and stimulate their enthusiasm and subjective initiative. The last point is not only limited to the evaluation of classroom teaching effect but also increases the evaluation of students' practical ability, including course experience, enterprise internship, competition, etc. Students should be encouraged to participate in Internet innovation and entrepreneurship competitions, Challenge Cup, etc. to improve their innovation ability. It is also necessary to combine classroom theoretical knowledge with practical activities and integrate practical skills into the course evaluation to promote students' overall development.

3.2. EVALUATION ANALYSIS OF THE DEGREE OF ACHIEVEMENT OF PETROCHEMICAL PROFESSIONAL COURSES

In this paper, we will take the graduation requirements of a university's petrochemical industry major as an example, and establish a support system for the cultivation of high-quality technical skills talents. For the division of specific index points, the division content is shown in Figure 2. The content of the first-level index includes whether one can operate and maintain the petrochemical unit equipment, whether one can control the operation of the petrochemical production unit, and whether one has the ability to analyze the production operation and deal with abnormal conditions. The secondary indexes mainly consist of core courses in oil formation physics, seepage mechanics, rock mechanics, oil recovery engineering, drilling engineering, and petroleum engineering big data. The specific weighting parameters of each index are detailed in Figure 2.

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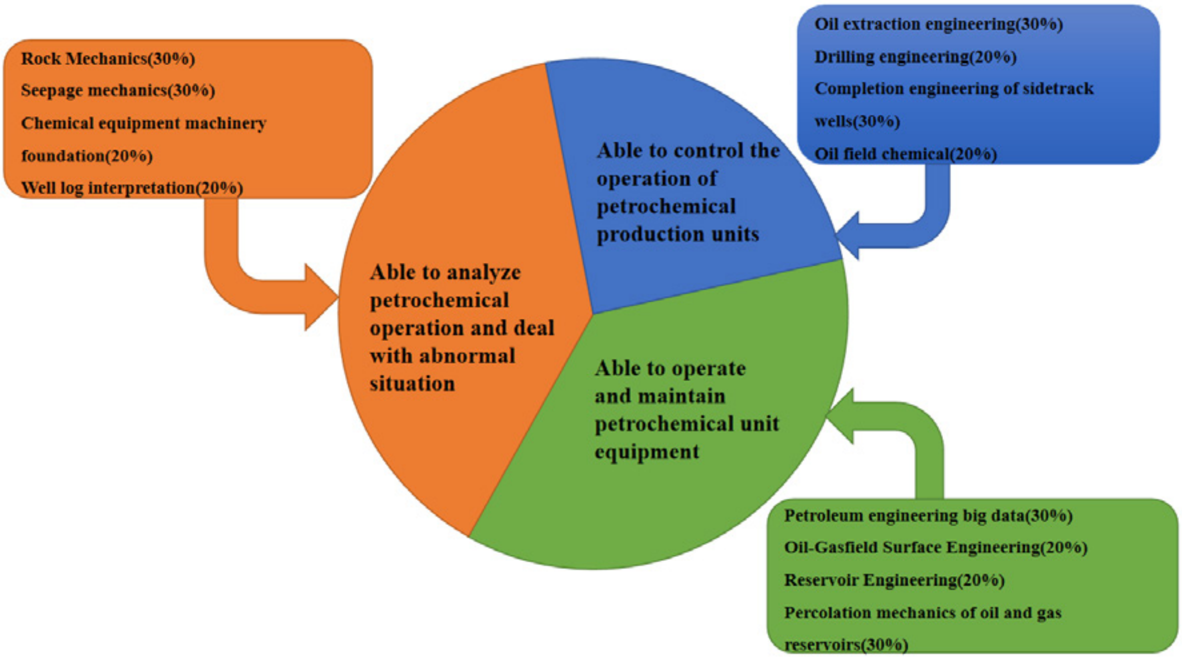

Figure 2. Example of correspondence between indicator points and supporting course system

According to the weight coefficients set for different courses, the degree of achievement of each graduation requirement index point can be calculated by weighted summation, as shown in equation (1).

$$Z = \sum_{i=1}^{m} a_i Y_i \tag{1}$$

Where: Z is the degree of achievement of each graduation requirement index point; Yi is the evaluation of course achievement; ai is the weight coefficient of the course to the index point; m is the number of courses corresponding to the index point.

The calculation method of course attainment is shown below.

The evaluation value of the petrochemical course on the index point attainment is calculated according to the formula shown below.

$$y_1 = Q_1 \times \frac{\bar{x}}{x} \tag{2}$$

Where: is the final assessment weight; x is the total score of the test questions related to the index point in the sample; is the average score of the test questions related to the index point in the sample.

Appraisal assessment evaluation value.

$$y_2 = Q_2 \times \frac{\bar{n}}{n} \tag{3}$$

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Where: is the process assessment weight; n is the total score of the class process assessment score; is the average score of the class process assessment score.

Practice assessment evaluation value.

$$y_3 = Q_3 \times \frac{\bar{p}}{p} \quad (4)$$

Where: is the weight of practical assessment; p is the total score of class process assessment results; is the average score of class process assessment results.

Course Attainment Rating Value.

$$y = y_1 + y_2 + y_3 \quad (5)$$

4. EXAMPLE ANALYSIS

4.1. ANALYSIS OF COURSE ATTAINMENT EVALUATION SCORES

This paper analyzes and compares students in Class 1 and Class 2 of the 2018 petrochemicals program at a university, where Class 1 underwent a reform of professional course teaching in the context of carbon neutrality in the current academic year, and Class 2 was taught by traditional teaching methods. The number of students in both classes is 50. The evaluation of course attainment of petrochemical industry majors used the course performance analysis method to quantitatively analyze the assessment results. The course attainment consists of three parts, which are course process assessment evaluation value, end-of-course evaluation value, and practical assessment evaluation value. The corresponding evaluation weights are 30%, 40%, and 30%, respectively. The specific size of the weight comes from the data reference in the research of the teaching system and the evaluation and analysis of the degree of curriculum achievement. The next course achievement evaluation analysis was conducted for Class 1 and Class 2, and the achievement evaluation values are shown in Figure 3.

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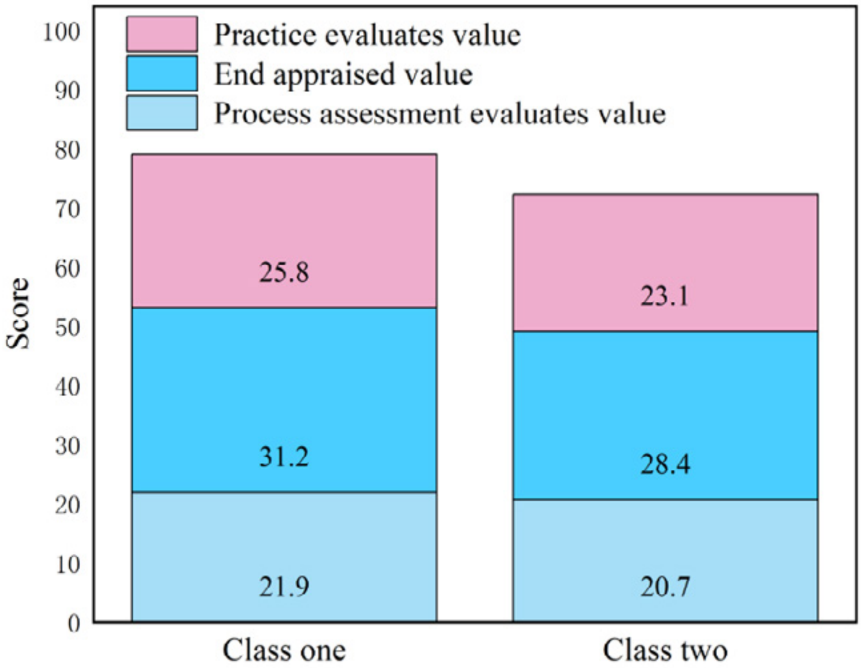

Figure 3. Course attainment evaluation scores of the Class of 2018 in petrochemicals

The evaluation scores of the two classes can be obtained from Figure 3, in which Class 1, which received the reformed instruction, has an overall score of 78.9, while Class 2, which did not receive the corresponding instruction, has an overall score of 74.6. It can be seen that the student's course attainment scores have improved after receiving the reformed instruction. For the three components that make up the score, the scores have improved to different degrees after the implementation of the reformed teaching program. For the course process evaluation score, the score increased from 20.7 to 21.9, an increase of 5.79%. The end-of-course evaluation score increased from 28.4 to 31.2, an increase of 9.85%. The practical assessment score increased from 23.1 to 25.8, an increase of 11.69%. It is easy to see from the increase of the three, that the increase of the practical assessment value is the largest among the three. The specific reason for this situation is to a large extent due to its composition. From the description above, we can find that the practical assessment value is composed of course experience, enterprise practice, and competition projects. Compared with the other two parts, this part pays more attention to the cultivation of students' practical abilities. As the practice is close to reality, students can be better exposed to cutting-edge development and broaden their insight. In addition, the extensive project participation and competition preparation provide practical experience that is not available in the previous classroom. As the course process assessment evaluation value with the smallest increase, it is only half the increase of the practical assessment evaluation value. This part is mainly composed of traditional teaching evaluation contents such as attendance, homework, class tests, and learning attitudes. Even if the corresponding reform teaching is carried out, the basic content still cannot jump out of this framework, which is the reason for the small increase. For the end-of-course evaluation value, the increase is within the two. This part of the course attainment score is basically a student assessment of the content and structure of the course, so the score depends on the student's self-perception of the course. The increase in this part of the score is not insignificant because of the greater optimization brought about by the curriculum reform.

Since the end-of-course assessment value is weighted at 40%, more attention should be paid to this aspect in the curriculum reform. However, the analysis above also reflects a very important point. Although the weight of the practical assessment evaluation value is relatively small, it has a high score increase. If more reforms are put into this point, good results may be achieved.

4.2. ANALYSIS OF COURSE CONTENT FEEDBACK

After the class, a questionnaire survey of teaching feedback was conducted for the Petrochemicals 1 class that had conducted the teaching reform of the professional course in the context of carbon neutrality, and the results are shown in Figure 4.

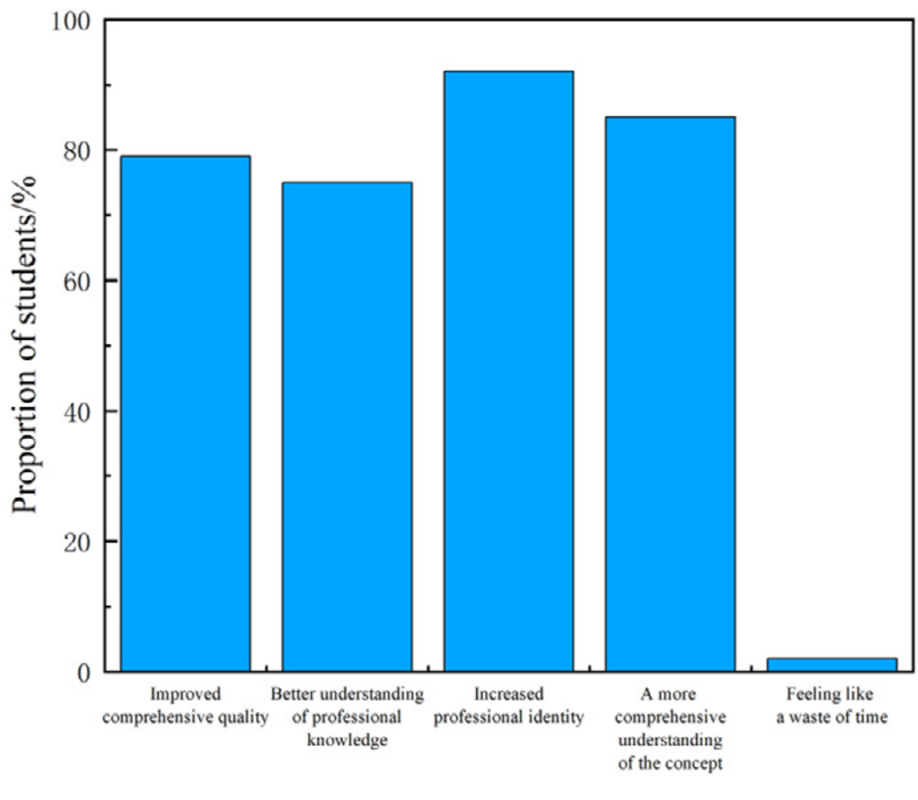

Figure 4. Students' feedback on course content in the context of "carbon neutrality"

In this questionnaire, it is very intuitive to see the students' views on the content changes with the curriculum reform. The survey consists of five main parts: for the improvement of their general quality, whether there is better help to understand the professional knowledge, for the increase of the professional identity, for the more comprehensive understanding of the concept, and whether they feel that they have wasted their time. For these five items, a high 92% of students expressed their approval in terms of increased professional identity. With the development of recent years, unlike the rapid development of various science and technology brought about

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by the upgrading of status, the status of the traditional petrochemical industry can be said to be in decline. This situation has actually indirectly led to a sense of extreme disapproval among petrochemical industry students in their own professional fields. However, it can be found that the new reformed teaching has led to a significant increase in student recognition. This is because the carbon-neutral context of the reform has allowed students to better understand the current state of their profession and to understand that innovations in their industry can contribute significantly to the achievement of carbon reduction goals. These increased perceptions are what increase the increased recognition of their profession. At the same time, it can be found that only 2% of the students feel that they are wasting their time, which can also reflect the satisfaction of the students with the course content under the teaching reform.

The approval ratings of 79%, 75%, and 85% for improving one's overall quality, better understanding of professional knowledge, and a more comprehensive understanding of concepts, respectively. Although not as high as the professional recognition, it is still a good level. Even so, it should be noted that nearly 20% of the students still think that they have not done enough to improve their overall quality and to help them better understand their professional knowledge. The reform of teaching has introduced a number of new methods, but not all of them are helpful. Any change in teaching methods should be based on the principle of improvement through trial and error, with positive adjustments based on student feedback. The 20% of the students who did not approve of the teaching method was the basis for subsequent changes. In the follow-up, it is necessary to provide better solutions to improve the overall quality of the students and to provide a better system of answers for the understanding of professional knowledge.

5. DISCUSSION

Under the current carbon-neutral background, there has been some progress in the curriculum teaching reform of the petrochemical industry in colleges and universities. On the one hand, the trend of the future direction of the industry in the new environment is explained in depth in the course, which can help students to recognize the current situation. On the other hand, strengthening the practical exercise for students has a certain guiding effect on students to find their own positioning in the industry. The development of these two aspects has largely led to a certain improvement in the backward teaching mode of the petrochemical industry. The newly trained talents can use more specialized knowledge to accomplish the goal of carbon neutrality.

Although various attempts and reforms are in full swing in various universities, not all new teaching theories are applicable to the reform of the petrochemical industry. The reform for such traditional engineering subjects should be a combination of theoretical innovation and enhanced practice. The new theoretical knowledge is taught in a way that is acceptable to the students and is really absorbed into their own knowledge system. For the expansion of the practical content, whether the students can accurately find the industry and their own positioning. Only when these things are really done can teaching reform be considered effective. In the current teaching environment, it takes a huge investment of time and cost to really achieve these elements, and it is not something that can be accomplished overnight. How to develop an effective program and follow a schedule to advance steadily should also be taken seriously by universities. Although carbon neutrality is a long-term goal, effective improvements in the petrochemical industry can accelerate the accomplishment of the goal. As a higher education institution that provides talent for the industry, it is important to carry forward the teaching reform of the petrochemical industry effectively with a great sense of responsibility.

6. RESULTS

In this paper, under the guidance of the teaching evaluation system based on the OBE concept, the students of Class 1 and Class 2 of a university's 2018 petrochemical class were investigated. Among them, Class 1 accepted the reformed teaching method, while Class 2 kept the existing teaching mode unchanged. Finally, the assessment results were analyzed quantitatively to obtain the professional course attainment evaluation scores and feedback on course content for both classes. After the analysis, the following conclusions were made.

1. In the distribution of the weights of the professional course achievement evaluation scores, the weights of the course process assessment evaluation value, the end-of-course evaluation value, and the practical assessment value are 30%, 40%, and 30%, respectively. When making improvements to the focus direction of the reform, the weighting percentage should be considered appropriately.

2. In the evaluation score, the combined score of class 1, which was subjected to reformed teaching, was 78.9, which was greater than the 74.6 of class 2, which maintained the existing teaching method. for the three components with the constituent elements, all three had some degree of increase. The practical assessment value increased the most, from 23.1 to 25.8, an increase of 11.69%. The course process assessment value increased the least, from 20.7 to 21.9, an increase of 5.79%. The end-of-course evaluation value increased moderately, from 28.4 to 31.2, an increase of 9.85%.

3. In terms of student feedback on the course content, 92% of the students expressed their approval in terms of increased professional identity, which is the maximum of the five components. In terms of improving their overall quality, better understanding of professional knowledge, and more comprehensive understanding of concepts, 79%, 75%, and 85% of the students approved respectively. Nearly 20% of the students thought that the reform was not enough in terms of improving their overall quality and helping them understand

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the concepts better. Only 2% of the students agreed with this opinion on whether they felt that they had wasted their time.

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