

Exploring OBE Concept in the Innovative Reform of Secondary School Chemistry Education



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Abstract: In recent years, the concept of Outcome-Based Education (OBE) has emerged as a central theme in higher education reform, with scholars adopting diverse approaches in their research frameworks and methodologies. Against the backdrop of globalization and the rapid development of information technology, OBE principles offer fresh perspectives and approaches for educational reform, prompting deeper reflections on educational quality and effectiveness. This paper employs a literature analysis to explore and synthesize the thematic focus, temporal distribution, and perspectives of studies published between 2012 and 2024. Furthermore, key areas of analysis include defining the concept of OBE, assessing its current applications, and evaluating its role in driving innovative reforms in high school chemistry education. In order to solve the core problem of how to improve the teaching quality of Secondary School Chemistry Education, this achievement takes the OBE teaching concept as the guide, adopts the student-centered teaching mode by reforming the teaching design, and achieves remarkable teaching and educating effects. This paper presents recommendations and reflections on the limitations of existing research and explores potential future directions for OBE studies. The constructing assessment tasks on carefully OBE principles, which are described in terms of learning performances, may enable educators to foster and examine much deeper levels of students' understanding.

Keywords: Outcome-Based Education (OBE); Innovative Teaching; Secondary School Chemistry Education

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1 Introduction

In the context of globalization and the rapid development of information technology, there is an increasing demand for multifaceted talents with innovative and complex problem-solving skills. Amid this trend, the limitations of traditional educational models have become increasingly apparent, as they struggle to address the urgent demands of talent cultivation in the new era.

Against this backdrop, the concept of Outcome-Based Education (OBE) offers fresh perspectives and approaches for educational reform, prompting deeper reflections on educational quality and effectiveness [1, 2]. As a critical component of OBE, reforming secondary school chemistry instruction plays an essential role in developing students' scientific literacy and practical

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skills. Whereas traditional chemistry education often emphasizes the transfer of knowledge, OBE concept advocates for curriculum and instructional design centered around targeted learning outcomes. This approach relies on backward design, where educators plan instructional content and methods based on the learning outcomes students are expected to achieve, thereby ensuring educational activities closely align with actual learning outcomes. [3, 4] In practice, OBE concept offers teachers clear instructional direction by setting specific learning objectives and assessment standards. In this process, teachers should not only focus on students' knowledge acquisition but also prioritize the development of skills and overall quality improvement. This outcome-focused model encourages students to engage in active learning, fostering continuous self-improvement, innovative thinking, and practical competencies. Furthermore, OBE concept emphasizes a flexible and diverse learning process. Through varied teaching strategies and methods, educators can better accommodate individual learning needs, supporting students as they explore and conduct research in their areas of interest. [5] This personalized learning model not only enhances students' motivation but also builds a strong foundation for their future career development. The OBE framework has brought transformative changes to secondary school chemistry education, providing a practical and effective foundation for nurturing innovative talents equipped to meet contemporary societal needs.

2 Background of OBE

The OBE concept was first proposed by American scholar Spady, which is a student-centered and result-oriented educational model that carries out a reverse instructional design system. One of its core elements is student-centered, mainly embodied in: first, teaching design is student-centered; second, resource allocation is student-centered; third, teaching evaluation is student-centered [6]. The OBE concept is significantly different from the traditional education concept, which changes the traditional education model around the teacher to carry out teaching, the student's passive acceptance of the teaching mode. It can effectively enhance the students' innovative spirit and practical ability, which is a kind of education concept innovation. It can effectively enhance students' innovative spirit and practical ability, and this is a kind of education concept in-

novation.

OBE is an acronym for Outcome-Based Education, which was first proposed by American scholar Spady and first appeared in the basic education reforms in the United States and Australia. In his book *Outcome-Based Education: Controversies and Answers*, Spady defined OBE as "the clear focusing and organizing of the education system around experiences that ensure students' substantial success in their future lives". The Australian Education Department defines OBE in an official document as an educational process based on the realization of specific student learning outcomes. Student outputs drive the operation of education, and educational structures and curriculum systems are seen as means rather than ends. If they do not contribute to the development of specific student competencies, (the original structure and curriculum system) should be rebuilt [7, 8]. Regardless of how it is defined, the foundational definition of the OBE philosophy is still the Outcome-Based Education philosophy, based on the OBE model as an instructional model in which educators predetermine the competencies or goals that students should obtain or achieve upon graduation. Specifically, the OBE design a rational and scientific instructional process that will help students achieve the expected goals for graduation, and then feed back to the instruction with the results.

Domestic research on the concept of OBE is relatively late, mainly from the 21st century, the common expression of domestic scholars on OBE is the concept of success-oriented education. In recent years, there are more studies on the reform of teaching in higher education, which is often linked with the teaching design of specific majors and permeates the process of talent cultivation. The concept of OBE is the concept of constructing the curriculum system which is centered on the students and oriented on the results, and which is carried out in the reverse way of thinking. The OBE (Outcome - Based Education) education concept adheres to the core principle of being student - oriented and, with the goal - oriented results as the direction, constructs an innovative curriculum system through reverse thinking. This model adopts the "reverse design" strategy, which refines the training objectives into a series of quantifiable and evaluable teaching standards. Subsequently, it carries out the teaching design based on the established objectives, enabling students to meet the requirements step by step. As an educational model that focuses on educational achievements, its evaluation system encompasses the

entire learning process, ensuring that the training objectives of students at each stage can be matched with the corresponding achievement standards and specific measurement standards, thereby realizing the comprehensive and meticulous monitoring of the teaching effect. At the same time, its teaching evaluation index emphasizes continuous improvement through a dynamic evaluation process [9, 10]. In essence, this approach begins with setting clear goals and designing a pathway to achieve them, with learning outcomes serving as both the foundation and endpoint of the teaching process. Graduate evaluations are based on whether these targeted outcomes have been met, effectively reflecting the extent to which graduates achieve the intended goals and supporting the development of application-oriented talents.

3 Application Overview

The enlightenment period of the education model based on the concept of OBE was in the 1950s, originated in the United States, matured in the 1980s and 1990s, and first appeared in the basic education reforms in the United States and Australia. In 1993, the National Medical Council of the United Kingdom formally introduced the theory of OBE, and introduced the requirements for medical graduates, which marked the beginning of the reform of medical undergraduate education in the United Kingdom. In 2005, the Finnie and Usher, Canadian experts in the field of public policy, proposed that OBE should become an important part of the quality evaluation framework of higher education, triggering the reform of quality evaluation in higher education [11, 12]. (As shown in Table 1)

Table 1 Overview of the application of the OBE concept (in 2012-2022)

Year	Overview of the application of the OBE concept
2012	With the Office of the Auditor General of Ontario, Canada, using student outcomes as an indicator for judging the quality of teaching and learning, the Ontario Ministry of Training, Colleges and Universities (OMTCU) began a sustained focus on learning outcomes and decided to select a number of pilot colleges and universities to develop evaluation practices.
2014	In the letter of appointment from the Prime Minister of Canada to the new Minister of OMTCU, it is stated that assessment of learning outcomes should be the top priority of the department. Based on the OBE concept, Hong Kong has implemented the "3+3+4" academic structure in the 2012/13 academic year, carried out curriculum reforms, improved the course selection system, and added new elements such as whole-person education to the pre-primary curriculum. Through the four-year education system, students can have a more balanced and holistic development.
2016	China has become a full member of the Washington Agreement, thus opening the curtain of China's professional accreditation of engineering education with international substantive equivalence, which also means that China will be committed to perfecting the educational and teaching reform centered on the concept of OBE.
2017	During the "13th Five-Year Plan" period, the Ministry of Education will vigorously promote the construction and application of online open courses in institutions of higher education. Based on the OBE concept society's actual demand for talents, emphasis is placed on organizing course construction around learning outputs, scheduling teaching time and designing key resources.
2019	The State Council promulgated the Implementation Plan for National Vocational Education Reform, which explicitly calls for actively promoting the high-quality development of higher vocational education, points out that higher vocational colleges and universities have to cultivate high-quality technical and skilled talents to serve the regional development, and draws on the common practice of international vocational education to launch the pilot work of 1+X certificate system, etc., which is fundamentally aimed at improving the quality of cultivating technical and skilled talents in higher vocational education. The "1+X" certificate system meets the requirements of the OBE concept for talent training, improves the quality of talent training, and emphasizes the cultivation of effective application-oriented talents in vocational education.
2022	Beijing Huaspei Education Science and Technology Institute organized the "Special Training Meeting on Talent Cultivation Program Development and Teaching Reform in the Context of the "Four New" Construction of National Institutions of Higher Education" to help teachers understand the connotation of the "Four New" construction, and to promote the teachers' teaching reform in all aspects, such as specialties, curricula and classrooms, with three core elements: student-centered, output-oriented and continuous improvement. Teaching reform, to three core: student-centered, output-oriented and continuous improvement as the focus, scientific and rational development of professional talent training programs and curriculum construction, the formation of training programs, teaching methods, teaching evaluation, teaching and rectification of the cycle of improvement, dynamic adjustment of the talent training mechanism.

4 Teaching Reform Strategies

The new curriculum emphasizes the development of core competencies in chemistry as a central theme. It proposes a senior secondary chemistry curriculum de-

signed to meet the diverse developmental needs of students, selecting content that reflects both the foundational and modern aspects of chemistry. The curriculum advocates for a "competency-based" teaching approach and promotes assessments focused on core chemistry competencies. Through this framework, the curriculum aims to

advance quality education, foster scientific spirit, enhance students' core competencies, and ultimately improve their quality of life. [13].

The OBE (Outcome-Based Education) concept emphasizes several key principles: defining the learning outcomes students are expected to achieve, based on educational objectives; understanding why these outcomes are necessary, driven by both internal and external demands; determining effective methods to help students reach these objectives through a structured cultivation process; assessing whether students have met the desired learning outcomes through targeted evaluations; and ensuring students' ability to achieve these objectives through continuous improvement initiatives. Addressing these five aspects, along with implementing the new senior secondary chemistry standards, can enable schools to streamline the

teaching process, focus resources on high-impact areas, and make chemistry instruction at the senior secondary level more purposeful and effective [14].

4.1 Orientation

Secondary school chemistry education is in the stage of basic education, which is the key period to shape students' chemical understanding, and to a certain extent affects students' choice of study majors in colleges and universities. Therefore, the OBE concept is result-oriented, learning outcomes are the end point of learning and the beginning point of learning, reasonable teaching objectives are the guide to reach good teaching outcomes, and the prerequisite for the reform of high school chemistry teaching is to design scientific and reasonable teaching objectives.

Table 2 Five Literacies in Chemistry proposed under the Chemistry Curriculum Standards for General High Schools (2017 Edition 2020 Revision)

Goal	Chemistry Core Literacy
To be able to recognize the diversity of substances at different levels and to classify substances; to be able to recognize the composition, structure, properties and changes of substances at the level of microscopic particles such as atoms and molecules, and to form the concept of "structure determines properties".	Macro-identification and micro-analysis
Be able to recognize that matter is in motion and change, know that chemical changes need conditions and follow certain laws; recognize that the essence of chemical change is the production of new substances, accompanied by energy conversion.	The concept of change and the idea of balance
Have an awareness of evidence and be able to formulate possible hypotheses about the composition and structure of substances and their changes based on evidence, and confirm them through analytical reasoning; establish logical relationships between ideas, conclusions and evidence; be able to recognize and study the essential characteristics of substances, their constituent elements and their interrelationships through analytical reasoning about evidence and build models; be able to use models to explain chemical phenomena and reveal the nature and laws of the phenomena.	Evidential Reasoning and Model Cognition
Recognize that scientific inquiry is a scientific explanation and discovery, creation and application of practical scientific activities; can find and put forward the problem of the value of inquiry; can start from the problem and assumptions, to determine the purpose of the inquiry, design the inquiry program, experimental investigation; in the inquiry will learn to cooperate, in the face of the "anomalous" phenomenon dares to put forward their own insights.	Scientific Inquiry and Creative Awareness
To have a rigorous and realistic scientific attitude, a sense of exploring the unknown and advocating the truth; to appreciate the significant contribution of chemistry to social development, to have a sense of sustainable development and the concept of green chemistry, and to be able to make correct value judgments on hot issues in society related to chemistry.	Scientific spirit and social responsibility

Table 2 outlines the five core competencies in chemistry as specified in China's General High School Chemistry Curriculum Standard (2017 edition, revised in 2020) issued by the Ministry of Education. These competencies embody the educational values upheld by chemistry education in China [15, 16], encapsulating the moral values, essential character traits, and key skills that students are expected to develop progressively through their study of chemistry. In alignment with one of the fundamental principles of Outcome-Based Education (OBE) — that needs shape educational objectives — these five competencies

reflect the national emphasis on fostering students' innovation and practical abilities. They align with OBE's student-centered philosophy, which focuses on cultivating core skills that empower students to solve problems and adapt to society. Consequently, curriculum reform based on OBE should not only address foundational knowledge but also incorporate practical activities to nurture relevant skills and qualities. Detailed objectives are essential in three domains: teaching foundational knowledge, developing practical skills, and cultivating chemistry-related competencies.

4.2 Design

Chemistry teaching is divided into basic knowledge teaching and experimental practice teaching. one of the principles of curriculum design of OBE concept is reverse design, i.e. to take the final teaching goal as the starting point, reverse the teaching design and carry out the teaching activities, to split the final learning outcomes of the students into a number of small goals during the teaching process, so that the students can reach the same learning goal at different levels of ability, at different times, and through different ways to ensure the appropriateness of the teaching process design and the learning outcomes and the role of effective teaching resources to the fullest. process design and the appropriateness of learning outcomes, and maximize the role of effective teaching resources. Therefore, the design of the teaching process of chemistry in high school should be strictly based on the teaching objectives, and the learning tasks should be divided into modules, so as to help students efficiently acquire the core literacy of chemistry.

The OBE concept emphasizes student-centeredness and advocates flexible teaching, allowing students to carry out their own learning in a more flexible way, to prove what they have learned and to demonstrate the results they have gained, making the teaching process easier and more flexible. Teachers can inspire students by adopting teaching methods such as heuristic teaching and experimental teaching method, and can also give play to students' subjectivity through group assignments and case studies to help students gain a deeper understanding of chemistry and cultivate their innovative and practical abilities. Schools can expand the space for students to learn chemistry knowledge through diversified and selectable chemistry curricula, and guide students with different levels of ability to learn different chemistry to achieve the same learning outcomes. Therefore, in order to let students become the protagonists of learning, teachers must change their roles from knowledge instillers to guides and collaborators, focusing on cultivating students' innovative ability, application ability and practical ability, and changing the phenomenon of "dead books" in traditional teaching. Teachers should reform the original teaching mode and mix various teaching methods to create an atmosphere for students' personalized development. Organic combination of knowledge and students need to achieve the ability to fine-tune the theoretical knowledge, the theory into practice, to provide students with a good learning atmosphere, encour-

age students to personalized development, to provide more innovative talents for the community.

On the one hand, the learning outcomes emphasized by the OBE concept are the abilities that students acquire through learning rather than the contents taught by teachers. While chemistry is an experimental subject, students' learning about chemistry requires setting up experiments through various known conditions and further reasoning to obtain core chemical literacy such as the spirit of scientific inquiry, practical hands-on ability and evidence-based reasoning ability. Therefore, the school should seek government and social help to improve the school chemistry laboratory equipment and experimental conditions, at the same time, teachers should be good at applying scientific and technological means to make up for the defects of the laboratory conditions, such as virtual laboratories, experimental teaching videos, etc. Combined with the teaching of the virtual experimental technology of the experimental demonstration or experimental manipulation, through the students' curiosity to play to enhance the students' enthusiasm for learning, and at the same time, virtual experimental technology can be the student's sensory experience. At the same time, virtual experiment technology can enhance students' sensory experience, to a certain extent, enhance students' scientific inquiry spirit and practical ability.

On the other hand, the principle of reverse design of the curriculum of OBE concept can be applied to experimental teaching, combined with the task analysis method, to determine the experimental objectives, derive the details of the knowledge, and further derive the relevant experimental steps, test the experimental steps, to complete the reverse design of the experiment, and to record the students' experimental process through the task analysis, so that the students can get the feedback of the experimental phenomena in time, and to make clear the link of the mistakes. Reverse design of chemical experiments helps to cultivate students' reverse thinking, reflecting the student's subjectivity, but also allows students to effectively consolidate the learning outcomes, is a very effective experimental training for students on the type of chemical experimental flowchart questions, to a certain extent, to make up for the students' hands-on experimental short board, but also for the experiments before the adequate theoretical preparation to reduce the risk of experimentation. At the same time, teachers can create a real situation to guide students to design practical industrial chemistry experiments, so that students pay

attention to the relationship between chemistry of human life.

In addition, the school should actively seek the help of relevant chemical enterprises to carry out research activities for students to build a good practical platform for students to learn from the theoretical classroom to the social practice, extend the students' learning space, break the "theory but not practice" of the situation of exam-oriented education, so that students can actually understand the application of chemistry in real life, and increase students' interest in learning chemistry. It can help students understand the application of chemistry in real life, increase students' interest in learning chemistry, and help some of them to make a firm choice of in-depth study of chemistry, so as to provide our society with chemistry application talents.

4.3 Evaluation System

The traditional education concept of teaching evaluation from the student's theoretical examination results of a single criterion for students to classify the grade, the grade cannot effectively distinguish whether the students have qualified practical ability, does not meet the requirements of the development of quality education, more does not meet the current social requirements to cultivate applied talents. OBE concept focuses on the ability and quality of the students, based on the realization of the key points of the concept of OBE, the teaching evaluation should focus on learning outcomes, including theoretical learning outcomes but not limited to this, using multiple and graded evaluation criteria, evaluation emphasizes the process of reaching learning outcomes and students' progress, and does not emphasize students' comparison with each other. The student is a unique person and should be evaluated in a targeted manner.

Regarding the evaluation of chemistry discipline, it should focus on the evaluation of students' comprehensive ability. Schools can pay attention to the application ability of students' chemistry knowledge by organizing events such as chemistry application competition and chemistry experiment innovation ability competition, etc. In the aspect of practical operation, it is necessary to reduce the proportion of test scores and increase the proportion of the performance and operation ability in the usual practical operation, to reduce the proportion of unnecessary courses by means of diversified evaluation and to increase the proportion of courses arranged for the practical ability of students. The proportion of practical

ability of the curriculum arrangements, which can stimulate students to participate in the enthusiasm of chemical innovation and practice competition, but also to improve the phenomenon of students "dead book". At the same time, through the achievement of students' learning outcomes, we can also test the teaching level of teachers, so as to form a favorable and mutually beneficial situation and promote the continuous improvement of the teaching mode.

4.4 Training Mechanism

The purpose of evaluation is to carry out teaching in a better way, so schools should provide timely feedback to teachers and students on the evaluation results, and then make improvements to the training objectives and teaching links, promote teaching reform in a sustainable way, and keep abreast of the times, so that the teaching process always presents a new look, and the learning outcomes of the students can meet the needs of the society. Therefore, in the process of high school chemistry teaching reform, it is necessary to grasp the cultivation requirements of high school students from the top-level design level, and formulate the matching cultivation system, professional quality standards, cultivation quality assessment rules, implementation rules and internal and external evaluation systems, etc., to ensure that the cultivation of talents is governed by rules and regulations. Through self-evaluation, student evaluation, mutual evaluation of teachers and other aspects of evaluation, the title and performance are linked to the results of teaching evaluation to improve the teaching level of teachers. Schools should provide timely feedback on the evaluation results and adjust the teaching activities of the school so that both students and teachers can improve their corresponding abilities and guarantee the quality of talent training in colleges and universities.

5 Conclusion

OBE concept has become a prominent focus in research on applied talent cultivation in recent years. However, existing studies still exhibit several limitations. Although there is substantial research on higher education reform and the training of applied talents, studies on specific curriculum design remain limited. Much of the current research is theoretical in nature and lacks sufficient empirical support. The implementation of OBE principles also

plays a crucial role in innovating secondary education. A review of the relevant literature reveals that there has been no systematic study exploring the integration of OBE with secondary education reform, highlighting this area as a research gap in need of further exploration by scholars. Expanding the application of OBE across different educational stages is essential.

In the era of rapid Internet and big data development, education must evolve to keep pace. Combining OBE concept with Internet technologies can help overcome temporal and spatial limitations, enabling more innovative research on OBE in the field of education. By leveraging Internet tools and big data analysis, OBE concept has the potential to drive changes and optimizations in educational models. The cultivation of applied talents is an urgent societal need. Universities should actively embrace their social responsibility by advancing research and practice of the OBE framework, innovating professional education models, and consistently supplying qualified talents to meet the evolving demands of society.

References

- [1] Xu L P, An P L, Xue R, etc Exploration and practice of BOPPPS education and teaching mode of college physics based on OBE concept [J]. *Science and Education Collection*, 2018 (36): 52-55.
- [2] Rao L. Research on the reform of practical courses from the perspective of "OBE" and "BOPPPS" [J]. *Contemporary Education Practice and Teaching Research*, 2021 (20): 107-109.
- [3] Zhang C. Reform of Hospitality English Teaching Based on the Educational Concept of Outcome-Based Education (OBE) [J]. *Journal of Contemporary Educational Research*, 2024, 8(1): 58-64.
- [4] Zhang T, Deng X. Teaching Reform and Practice of Embedded System Design Based on Outcome-Based Education [J]. *Journal of Contemporary Educational Research*, 2024, 8(3): 13-18.
- [5] Criswell B A, Rushton G T. Activity structures and the unfolding of problem-solving actions in high-school chemistry classrooms [J]. *Research in Science Education*, 2014, 44: 155-188.
- [6] Niu K. Research on "mixed" teaching results based on OBE concept and BOPPPS teaching mode [J]. *Journal of Education and Educational Research*, 2023, 2(2): 79-81.
- [7] Li J, Yang M A, Xue Z H. CHEMTrans: Playing an Interactive Board Game of Chemical Reaction Aeroplane Chess [J]. *Journal of Chemical Education*, 2021, 99(2): 1060-1067.
- [8] Li J, Yang M A, Weng M Y, et al. The Design and Research of Diversified High School Chemistry Homework in the Context of "Double Reduction" [J]. *Education Research and Development*, 2022, 1(1): 64-69.
- [9] Izci K, Muslu N, Burcks S M, et al. Exploring effectiveness of classroom assessments for students' learning in high school chemistry [J]. *Research in Science Education*, 2020, 50: 1885-1916.
- [10] Tan W, Ban L, etc. Daming Research and practice of curriculum reform based on OBE+BOPPPS – taking engineering drawing course as an example [J]. *Science and Education Guide*, 2022 (4): 76-78.
- [11] Liu F. Application and Implementation of Flipped Classroom in College Chemistry Teaching under the OBE Concept [J]. *Frontiers in Educational Research*, 2023, 6(14):94-100.
- [12] Magtolis J B M. Towards outcomes-based practice in science education [J]. *GPH-International Journal of Educational Research*, 2021, 4(01): 01-14.
- [13] Zheng W, Wen S, Lian B, et al. Research on a sustainable teaching model based on the OBE concept and the TSEM framework [J]. *Sustainability*, 2023, 15(7): 5656, 1-21.
- [14] Katawazai R. Implementing outcome-based education and student-centered learning in Afghan public universities: the current practices and challenges [J]. *Heliyon*, 2021, 7(5): 1-15.
- [15] Shan X. Exploration of Teaching Reform in Higher Mathematics Based on OBE Concept [J]. *Frontiers in Educational Research*, 2024, 7(2): 172-177.
- [16] Ni C. Research on Two way Driven Teaching Mechanism of Higher Mathematics and Discipline Competition for Economics and Management Majors under OBE Philosophy. *International Journal of Social Science and Education Research*, 2023, 6(1): 166-173.