

An Evidence-based Meta-analysis on the Outcomes of Teacher Education under the Concept of Outcome-Based Education

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Abstract: Currently, there is limited empirical research on the educational outcomes of Outcome-based Education (OBE) theory, making it challenging to draw clear inferences based on logical deductions in real-world contexts. Taking a certain university in Wuhan city as an example, this study conducted 50 regression analyses on the curriculum as the research subject, employing both Meta-analysis and Meta-regression analysis as natural experiments. The findings reveal that the implementation of OBE reforms significantly enhances the educational outcomes of teachers, although the impact shows substantial heterogeneity. Firstly, the classroom learning environment has a significant positive impact on educational outcomes. Secondly, the study found that implementing OBE reforms has significantly positive effects on professional courses and platform courses, while showing insignificant effects on general education and elective courses. Thirdly, the effects of OBE reforms are more pronounced for students in science and engineering as well as business and management disciplines, whereas insignificant for students in humanities and arts disciplines. Based on these findings, the following policy recommendations are proposed: there should be a firm commitment to the implementation of OBE reforms, and it is advisable to expand the scope of OBE reforms to a larger scale. Furthermore, OBE reforms can be selectively implemented across all courses, and efforts should be made to ensure clarity of objectives when implementing OBE reforms in disciplines related to humanities and arts.

Keywords: OBE; Educational Outcomes; Meta-analysis; Meta-regression Analysis.

1. Introduction

Outcome-based education (OBE) is an instructional reform approach that shifts the focus of learning from course content to students' learning outcomes or abilities. OBE emphasizes student-centered teaching, with an emphasis on cultivating students' learning outcomes and fostering independent learning abilities. By clearly defining learning objectives and encouraging student participation, OBE instructional reform can effectively enhance the quality and outcomes of student learning.

Characteristics of OBE instructional reform include the following aspects: 1) Clear learning objectives: OBE provides clear learning objectives, specifying the knowledge, skills, and attitudes that students need to master, as well as how to assess their learning outcomes. By doing so, both students and teachers become aware of the objectives they need to achieve, enabling more targeted teaching and learning. 2) Emphasis on student participation: OBE emphasizes student agency and encourages active involvement in the learning process. Teachers play the role of guides and supporters, facilitating students to develop their own independent learning strategies. 3) Feedback and assessment: OBE emphasizes the assessment of student learning outcomes, promoting the use of various assessment methods, including project assignments, verbal expressions, and practical activities. This allows for a more comprehensive understanding of student learning and provides timely feedback to facilitate their improvement. 4) Selection and design of teaching materials: OBE requires the selection and design of teaching materials that are based on learning objectives. The materials should be carefully chosen to be directly related to students' learning objectives and assist them in achieving their goals. Teachers can select different

teaching resources and strategies to address the diverse learning needs of students. 5) Interdisciplinary learning: OBE encourages interdisciplinary learning, helping students integrate knowledge and skills from different disciplines to develop their comprehensive abilities. This enables students to better understand and apply what they have learned, enhancing their problem-solving and critical thinking skills.

To evaluate the effectiveness of OBE instructional reform, various research methods can be used, including meta-analysis and meta-regression analysis. Meta-analysis involves synthesizing the effect sizes from multiple independent studies to obtain a statistical summary of the overall effect. Meta-regression analysis, on the other hand, examines the relationships between educational effects and various factors by analyzing the influences of different factors across multiple studies.

In order to evaluate the effects of OBE education through meta-analysis, researchers need to undertake several steps. First, they should collect relevant literature and then screen studies that meet specific criteria. Once the criteria are applied, researchers can extract effect size data from these selected studies. Subsequently, statistical analysis is undertaken to merge the effect sizes and obtain the overall effect and confidence interval. By taking this approach, a comprehensive assessment of the impact of OBE instructional reform on student learning quality and outcomes can be achieved.

In conducting meta-regression analysis to evaluate the effects of OBE education, researchers consider educational effects as the dependent variable and various factors related to OBE education (such as student participation, teacher guidance methods, assessment methods, etc.) as independent variables. By analyzing the statistics, researchers can assess

the contribution levels of different factors to the effects of OBE education, thereby optimizing and improving the implementation of OBE instructional reform.

In conclusion, outcome-based education (OBE) is an student-centered teaching approach. It enhances the quality and outcomes of student learning through clear learning objectives, student participation, feedback and assessment, the selection and design of appropriate teaching materials, and the encouragement of interdisciplinary learning. When evaluating the effects of OBE education, research methods such as meta-analysis and meta-regression analysis can be employed to explore the impact on student learning and the influencing factors. This provides evidence-based guidance for educational decision-making and practices.

The concept of Outcome-Based Education (OBE) has rapidly spread across China and Hubei Province in recent years, leading universities to initiate teaching reforms based on OBE principles. After several years of implementation and development of OBE, it has become necessary to evaluate the changes in teaching effectiveness under the OBE paradigm. However, current assessments of the implementation of OBE in universities tend to attribute all teaching achievements to the implementation of OBE alone, which confuses the cause-and-effect relationship and fails to accurately identify the true effects of OBE implementation.

Regarding the evaluation of teaching effectiveness, evidence-based education research has been gradually gaining popularity. Domestic scholars have begun exploring the use of evidence-based methods to assess teachers' educational effectiveness. However, current research in China mostly remains at the introductory and speculative stage, with only a few empirical analyses conducted using an evidence-based approach. Meta-analysis, as a mainstream and advanced method in evidence-based education research, has garnered widespread recognition and attention. However, there is currently a lack of academic achievements in China utilizing the meta-analysis technique to study teacher education effectiveness.

2. Literature Review

2.1. Research on OBE Teaching Philosophy

OBE, or Outcome-Based Education, is an education approach that focuses on outcomes and has gradually formed a relatively complete theoretical system. One major advocate of OBE is Spady. The development of OBE is based on the educational ideas of five major education reform movements (Malan, 2000). These include the educational objectives movement, which is based on Tyler's principles and Wheeler's model; the competency-based movement that emerged in the late 1960s; Bloom and Guskey's mastery learning movement; performance-based reference evaluation; and integrated education proposed by Malan and others. According to the concept of OBE, every aspect of the education system is built around educational goals or outcomes. In this approach, teachers can switch between roles as lecturers, trainers, helpers, and mentors (Qi Xianwen, Yang Fan, 2021).

Research on OBE teaching philosophy in China primarily focuses on two aspects. First, scholars have been introducing the OBE concept and discussing various methods of talent cultivation that align with the OBE philosophy (Qi Xianwen, Yang Fan, 2021; Li Yiqiang, Lin Caimei, 2021; Liu Jiafu, 2021; Zhang Min, 2019). These studies aim to provide a theoretical foundation for OBE implementation in Chinese

higher education. Second, researchers have investigated the implementation of OBE principles in specific majors or courses, examining the reform practices within these contexts (Zhang Ruilin, 2019; Zhang Xiaoju, 2019; Zhang Yuwei, Huang Ying, 2019; Liu Chunyu, Zhang Ruilin, 2019). Such studies offer insights into the practical application of OBE philosophy in the Chinese higher education system.

2.2. Research on Evidence-Based Education

Evidence-based education reform originated in Western medicine. As a new educational reform paradigm, evidence-based education refers to the scientific implementation of educational decision-making and practices based on the best research evidence to enhance educational quality. Research on evidence-based education in China started relatively late. Currently, research mainly focuses on introducing the concept, characteristics, and value of evidence-based education, while also highlighting its limitations. Chen Huan Chun and Jiang Guiyou (2021) suggest that excessive emphasis on evidence and empirical measurement while neglecting the uniqueness and complexity of education can lead to the education reform being trapped in statistical reductionism and detached from teachers' professional knowledge and experience. Moreover, evidence-based research in the field of education in China is currently limited, with few studies focused on medical education, where evidence-based research originated (Han Yangjun, 2020; Cui Youxing, 2021; Yan Yufeng et al., 2020).

Overall, the following issues exist in both domestic and international research: Firstly, there is a lack of research on the teaching effectiveness of OBE, especially empirical research. In some current reports on OBE education effectiveness in universities, all teaching achievements since the implementation of OBE are attributed solely to the implementation of OBE, which confuses the cause-and-effect relationship and fails to accurately identify the educational effects of OBE. To address this gap, it is essential to conduct empirical research that specifically examines the teaching effectiveness of OBE. Moreover, current research on OBE teaching philosophy rarely involves empirical research on educational effects, making it difficult to determine if logical inferences can be reproduced in real-world scenarios. Therefore, it is important to conduct empirical research that can validate the logical inferences drawn from the OBE teaching philosophy. This study aims to address these issues through empirical analysis.

Secondly, although the importance of evidence-based education is recognized in China, there is a severe lack of empirical research on evidence-based education, particularly the use of meta-analysis. Meta-analysis is widely applied in the field of medicine but remains limited to the field of economics and management in the humanities and social sciences. In the field of education, specifically, the application of meta-analysis is particularly lacking. To fill these gaps, this research aims to explore the teaching effectiveness of teachers under the OBE teaching philosophy by utilizing evidence-based research methods. This approach, incorporating meta-analysis, holds both theoretical and practical significance.

3. Research Design

To authentically represent the effectiveness of teacher education under the OBE concept, this study utilizes standard regression analysis. In order to achieve this, a regression model is constructed for each course, with the dependent variable being the implementation effect of OBE for that

specific course. The independent variables considered in the model include the student's college entrance examination scores, gender ratio, freshman year English scores, freshman year math scores, freshman year first semester average scores and standard deviation, as well as the implementation of OBE. In total, 50 regression models are constructed. Furthermore, each model is treated as a natural experiment, and Meta-analysis is employed to explore the combined effect of OBE implementation on students' academic performance. Lastly, META regression analysis is performed to identify the factors influencing OBE reform. The specific details of this process are as follows:

3.1. Research on OBE Teaching Philosophy

To examine the impact of implementing OBE reform on the effectiveness of teacher education, the study establishes the following variables:

OBE Implementation Effect (xg): Since the difficulty levels of exams can vary, using exam scores as a measurement after OBE reform is not appropriate. Based on the characteristics of OBE reform, this study adopts the absolute difference in the percentage of target 1 and target 2 scores in a specific course as the indicator for OBE implementation effect. Only students in the top 70% of class performance are considered to exclude the influence of learning attitudes. Therefore, $xg = (1 - |Target\ 1\ Score/Target\ 1\ Total\ Score - Target\ 2\ Score/Target\ 2\ Total\ Score|)$, where a course with three or more targets will only consider the first two targets.

College Entrance Examination Scores (lngk): The actual scores are used in the model, and the natural logarithm is taken.

Gender (xb): Male students are assigned a value of "1," while female students are assigned a value of "0."

Freshman Year First Semester English Scores (lnyy): The actual scores are used in the model, and the natural logarithm is taken.

Freshman Year First Semester Math Scores (lnsx): The actual scores are used in the model, and the natural logarithm is taken.

Freshman Year First Semester Average Scores (lnpj): Actual scores are used in the model, and the natural logarithm is taken. Scores from military training, physical education, and national defense education are excluded.

Standard Deviation of Freshman Year First Semester Average Scores (bzc): The actual value is used in the model.

OBE Implementation (obe): A value of "1" is assigned if OBE is implemented, and "0" is assigned otherwise.

3.2. Meta-Analysis and Meta Regression

Evidence-based practice, rooted in evidence-based medicine, signifies the integration of the best available research evidence, professional expertise, and patient values in medical treatment. The concept of evidence-based practice has gradually penetrated adjacent disciplines, such as evidence-based psychotherapy, evidence-based education, and evidence-based sociology, resulting in dozens of new disciplinary fields. META and meta regression analysis have emerged as significant evidence-based research methods. Though the current literature on meta-analysis mainly focuses on the synthesis of previous research findings, synthesizing reproducible experiments also represents an important logical approach. While it is not feasible to conduct reproducible experiments in the field of education, conducting a meta-analysis based on quasi-natural experiments can be conducted.

The steps for META meta-analysis and META regression analysis are as follows:

First, we conduct regression analysis using the aforementioned variables. We perform 50 rounds of regression analysis and encode the following variables:

OBE Implementation Effect (ssxy): This variable represents the original regression coefficient of OBE implementation in the model.

Precision of OBE Implementation Effect (ssxyp): We use the reciprocal of the standard deviation of the regression coefficient of OBE implementation as the variable in the model.

Class Situation (bj): This variable evaluates whether a class has received academic awards, indicating an excellent learning atmosphere. We assign "1" if the class has received recognition, otherwise "0".

Course Type: We categorize course types into general courses (tsk), platform courses (ptk), discipline-specific courses (zyk), and elective courses (xxk). If a course belongs to a specific type, it is assigned "1"; otherwise, it is assigned "0".

Major Type: This variable classifies majors into STEM disciplines (lgk), economics and management disciplines (jgl), humanities and social sciences (wfl), and arts subjects (ysl).

Gender Ratio (nvbl) and Urban-Rural Ratio of Students (cxbl): We use actual data as variables in the model.

Teacher-Student Evaluation Scores (lnxspf) and Teacher-Supervisor Evaluation Scores (lnddpf): We use actual data and apply the natural logarithm.

Then, based on the above coding, each regression model is treated as a natural experiment for META meta-analysis. Subsequently, META regression analysis is conducted to identify the factors influencing the OBE implementation effect.

4. Empirical Analysis and Results

4.1. Results of Standard Regression Analysis

Considering a university in Wuhan City as an example, the implementation of Outcome-Based Education (OBE) reform started in 2018. Nevertheless, not all majors and courses have gone through the OBE reform process, which offers an opportunity for comparative analysis in this study. Below, you will find descriptive statistics for all the data.

Table 1. Descriptive Statistics of Each Variable

Name	Obs	Mean	Std.	Min	Max
xg	1520	0.6724	0.421	0.12	1
lngk	1520	6.1734	1.1031	6.1012	6.2917
xb	1520	0.492	0.014	0	1
lnyy	1520	4.3567	2.127	4.2767	4.5850
lnsx	1520	4.3041	2.224	4.2485	4.5747
lnpj	1520	4.3175	1.010	4.2485	4.5433
bzc	1520	1.324	1.241	0.2147	4.5241
obe	1520	0.7	0.018	0	1

The results of the regression analysis are presented below (only ten studies are reported).

According to the results of the regression analysis of 50 studies, the implementation of OBE reforms has both positive and negative effects on the effectiveness of teacher education. However, it is important to note that there is considerable variation among the different studies. This variation

highlights the need for further analysis of these regression results.

Table 2. Regression Analysis Results (Including Ten Studies)

Name	Obs	Mean	Std.	Min	Max
1	0.0148	0.001	0.0044	0.612	-0.53
2	0.0124	0.000	0.0039	0.741	1.00
3	-0.0041	0.102	0.0005	0.417	-0.34
4	-0.0400	0.041	0.0042	0.217	0.74
5	0.0025	0.002	0.0060	0.598	2.46
6	0.0114	0.001	0.0076	0.678	1.64
7	0.0206	0.005	0.0085	0.772	-0.48
8	0.0184	0.000	0.0010	0.714	-1.29
9	0.0076	0.000	0.0086	0.814	0.14
10	-0.0046	0.210	0.0014	0.319	0.43

4.2. Meta-analysis Results

The presence of heterogeneity among different studies is a natural occurrence in meta-analysis. It refers to the variation in results observed across these studies. In the non-experimental regression analysis mentioned earlier, it is important to acknowledge that the choice of modeling and methodology can have a substantial impact on the reported results. Therefore, when conducting meta-analysis, it is crucial to carefully evaluate and account for this heterogeneity among the included studies. When significant heterogeneity is present, it becomes challenging to accurately capture the true nature of the issue being explored through any single method of measuring the average effect size.

One commonly used tool to assess heterogeneity is the Q-test, which follows a chi-square distribution with (k-1) degrees of freedom, where k represents the number of studies. The p-value obtained from this test is usually compared to a predetermined significance level, often set at 0.1. A p-value below this threshold suggests the existence of heterogeneity among the studies, with larger Q-values indicating greater heterogeneity.

In the context of the aforementioned heterogeneity test, the meta-analysis yields Q-values of 1217.584 (p=0.000, p<0.001). These values correspond to I² statistics of 90.223% and H statistics of 3.7. With a Q-value of such magnitude and I² statistics surpassing 90%, in addition to H statistics exceeding 1.5, it can be concluded that a high degree of heterogeneity is present among the studies.

Given the significant heterogeneity among the included studies, it is appropriate to employ a random-effects model for the meta-analysis. The results obtained from this analysis are as follows:

Table 3. Meta-analysis Results

Estimate	Std.	Var	95% Lower
0.0107	0.009	0.001	0.008
95% Upper	Z-value	P-value	Q-value
0.0213	20.811	0.000	1217.58

The table above shows that, after conducting a meta-analysis, the average effect size of implementing OBE reforms on the effectiveness of teacher education is 0.0107. Additionally, the 95% confidence interval does not include zero, which suggests a statistically significant effect.

4.3. Meta-regression Analysis

Given the high heterogeneity observed in the previous analysis, a meta-regression analysis was conducted to explore the sources of heterogeneity. In this study, the restricted maximum likelihood (REML) method was employed to estimate the between-study variance component, with the inverse of the effect size variance serving as weights. To estimate p-values, Monte Carlo permutation tests were used, and a correction was applied to the variance of the estimated coefficients. Additionally, t-distributions were used instead of the standard normal distribution when calculating p-values and confidence intervals. The estimated results are as follows:

Table 4. Meta-regression Analysis Results

Moderating Factor	Regression Coefficient	Standard Error
ssxyp	0.000141	0.0003642***
bj	0.002465	0.0060932***
tsk	0.000145	0.001547
zyk	0.006238	0.0071842***
ptk	0.005412	0.001451**
xk	-0.002012	-0.0121419
lgk	0.007142	0.001874***
jgl	0.004874	0.002145**
wfl	-0.001245	0.054128
ysl	0.001289	0.0098745
nvbl	0.006587	0.001587*
cxbl	-0.004128	0.0019874
lnxspf	0.001987	0.002187***
lnddpf	0.001899	0.001248***
tau2	0.000744	
I-squared	72.57%	
Adj R2	49.64%	
F	178.81	

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Based on the analysis results and the relevant content of Outcome-Based Education (OBE) reform, the following improvements have been made to enhance the logic and coherence among sentences within the paragraph:

The implementation of OBE reform significantly enhances teachers' educational effectiveness. Additionally, OBE instructional reform also involves some changes in teaching management, such as: setting clear learning objectives and assessing student learning outcomes. However, the core focus of OBE instructional reform lies in the transformation of teaching methods and changes in student learning processes. OBE instructional reform emphasizes the importance of student agency and active learning, as well as student engagement and autonomous learning. Under OBE teaching, teachers assume the role of guides and facilitators, providing learning resources, guidance, and feedback. The ultimate goal of OBE instructional reform is to cultivate students' comprehensive abilities, enabling them to achieve a series of expected learning outcomes.

By clarifying learning objectives, designing appropriate teaching materials, and organizing interdisciplinary learning, OBE instructional reform aims to improve students' learning outcomes and quality through changes in teaching methods and learning processes. Therefore, it can be said that OBE reform is a pedagogical method reform that focuses on

student-centeredness, student learning processes, and outcomes. It imposes certain requirements on teaching management reform while remaining centered on the transformation of teaching methods. Meta-analysis indicates that the implementation of OBE reform significantly enhances teachers' educational effectiveness.

2) The implementation of OBE reform exhibits significant heterogeneity in its impact on teachers' educational effectiveness. Firstly, the classroom learning atmosphere significantly influences educational effectiveness positively, which also reflects the principle of mutual learning. This result is expected.

Secondly, in terms of course types, OBE reform has a significant positive impact on the educational effectiveness of teachers in professional courses and platform courses, while its impact on general courses and elective courses is not significant. The reasons for this can be attributed to the fact that both teachers and students usually attach more importance to professional courses and platform courses, with students investing more effort in these courses. Additionally, the learning objectives of professional courses and platform courses are clearer, and the assessment of these courses can more precisely differentiate the intended learning outcomes being tested. In contrast, the learning objectives of some general courses and elective courses are difficult to pinpoint, often resulting in integrated questions in course assessments that make it challenging to distinguish the specific learning outcomes being tested.

Thirdly, with regards to students' majors, the impact of OBE reform on the educational effectiveness of students majoring in science, technology, engineering, and mathematics (STEM) and business and management is more significant, while its impact on students majoring in humanities and arts is not significant. The rationale behind this lies in the fact that the abilities of STEM and business and management students primarily manifest as "hard skills," which can be more easily quantified. In contrast, the abilities of humanities and arts students are predominantly "soft skills," which are difficult to quantify accurately and precisely. Additionally, the setting of course objectives and assessments in STEM and business and management courses is clearer, whereas objectives and assessments in humanities and arts courses often overlap, making it difficult to define specific learning objectives.

Fourthly, concerning classroom characteristics, the gender ratio has a positive significant impact on the educational effectiveness of teachers under OBE reform. The main reason for this being that male students have higher representation in STEM majors, while female students are more prevalent in humanities and arts majors. Therefore, although the gender ratio has a statistically significant positive impact on teachers' educational effectiveness under OBE reform, there is no direct causal relationship.

Fifthly, both student ratings and supervisory ratings significantly influence teachers' educational effectiveness under OBE reform. Although these ratings are statistically significant, they do not establish a direct causal relationship with teachers' educational effectiveness under OBE reform. Instead, they merely indicate that under OBE reform, student ratings and supervisory ratings can accurately reflect teachers' educational effectiveness, further validating the appropriateness of the measurement method employed in

5. Conclusion and Policy Recommendations

The conclusions of this study are as follows: Firstly, the implementation of Outcome-Based Education (OBE) reforms significantly enhances the educational outcomes of teachers. OBE reform is a pedagogical method aimed at student-centeredness, focusing on the students' learning process and outcomes. While it poses certain demands on instructional management reforms, the core lies in transforming instructional methods. Secondly, the impact of implementing OBE reforms on teachers' educational outcomes varies significantly. Specifically, the class learning environment plays a crucial role in determining educational outcomes, reflecting the principle of mutual learning. Additionally, the impact of OBE reform on different curriculum types differs. It has a significant positive impact on the educational outcomes of professional courses and platform courses, while the impact on general education courses and elective courses is not significant. Thirdly, the influence of OBE reforms on educational outcomes is dependent on students' majors. It has a more pronounced impact on educational outcomes for students in science, technology, engineering, and management majors, while the impact on humanities and arts majors is not significant. Lastly, under the current OBE reform, the accuracy of student assessments and supervisory evaluations in reflecting teachers' educational outcomes is confirmed. The methods employed in this paper to measure educational outcomes under OBE reforms are deemed appropriate.

Based on the above conclusions, the following policy recommendations are made. Firstly, there is a need to reaffirm the determination to promote the implementation of OBE reforms and expand its implementation on a larger scale. In the research, some teachers mistakenly viewed OBE reform as a metaphysical innovation in instructional management, believing that it did not significantly enhance the quality of teaching and education. However, through 50 regression analyses and subsequent meta-analysis, this study concludes that OBE reforms have significantly improved the quality of teachers' education. Therefore, it is crucial to dispel the misconception and highlight the positive impact of OBE reforms on teaching quality. While OBE reform poses certain demands on instructional management reforms, the transformation of instructional methods remains its core.

Secondly, OBE reforms can be selectively implemented across all courses. Professional courses and platform courses have clearer objectives and can better distinguish the objectives being assessed in course examinations. On the other hand, it is more challenging to define the objectives of some general education courses and elective courses. In course assessments, most questions tend to be comprehensive, making it difficult to clearly identify the objectives being assessed. To promote effective implementation of OBE reforms, it is recommended to focus initially on professional courses and platform courses that have well-defined objectives and easily assessable outcomes. Therefore, promoting OBE reforms for professional courses and platform courses should be encouraged, while the necessity of implementing OBE reforms for general education courses and elective courses needs further discussion.

Thirdly, when implementing OBE reforms for majors in humanities and arts, efforts should be made to clarify the objectives. It is essential to bear in mind that the abilities of

students majoring in humanities and arts are predominantly reflected in soft skills, which are more challenging to precisely quantify. From the perspective of curriculum and examination objectives, there is often an overlap in the objectives of courses and assessments, making it difficult to define the objectives clearly. Therefore, in order to deepen the implementation of OBE reforms, it is imperative to further clarify the objectives of courses and assessments.

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