Research and Practice of Precision Evaluation in Blended Learning Context

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***Abstract*—Precision evaluation plays a vital role in improving students' blended learning performance. In accordance with the teaching philosophy of Outcome-Based Education (OBE) and education requirements in China, this paper put forward a Three-stage Blended Learning and Evaluation (TsBLE) method to improve students' learning performance. The TsBLE method assumes that the blended learning process can be divided into three stages: pre-class online autonomous learning, in-class off-line in-depth research and after-class consolidation. Based on this assumption, the TsBLE method emphasizes that precision evaluation in blended learning should be multi-dimensional and fine-grained. Teaching practice was carried out to evaluate the effectiveness of the TsBLE method. The results showed that this method can effectively improve students' learning performance and help teachers adjust teaching strategies in time.**

***Keywords*—blended learning, precision evaluation, outcome-based evaluation, learning performance**

I. Introduction

Blended learning can effectively meet the students' personalized learning needs and solve the problem that traditional education cannot take into account both large-scale and personalized. Lots of researchers and educational institutions reach consensus that blended learning is becoming the "new normal" of future education [1, 2]. Meanwhile, it has been pointed out that precision evaluation is one of the keys to improve students' blended learning performance [3].

Many researchers have made efforts to design and implement blended learning evaluation based on learning process data. Bowyer and Chambers [4] proposed a new blended learning evaluation framework. This new framework is a coherent and overall framework which help researchers analyze the relationship between different aspects of blended learning. Ozer ova [5] used a learning management system to collect data of students' self-regulated online learning, and analyze the interaction mode between students and learning materials. A learning evaluation algorithm was proposed based on those data. Li and Han [1] established the principles of blended learning evaluation by analyzing the theoretical basis of blended learning. Taking learning process into account, they propose a blended learning quality evaluation system. This system provides a reference for teachers of different disciplines to carry out blended learning evaluation.

In recent years, the teaching philosophy of OBE is used to guide evaluation of blending learning. OBE emphasizes using results to evaluate students' learning performance. Guided by OBE, some researchers have carried out blended learning evaluation by calculating the degree of achievement of curriculum objectives [6–8].

In order to provide students with more timely and personalized feedback, this paper uses both learning process data and learning results for precision evaluation. This idea is consistent with the principle of "improving result evaluation, strengthening process evaluation, exploring value-added evaluation, and improving comprehensive evaluation". The principle was put forward in the General Plan for Deepening the Reform of Education Evaluation in the New Era by the State Council of China. Following the above principle and the teaching philosophy of OBE, this paper put forward a Three-stage Blended Learning and Evaluation (TsBLE) method to improve students' learning performance by providing precision evaluation. Specifically, the development of TsBLE method includes designing a three-stage blended learning process, constructing a multi-dimensional and fine-grained precision evaluation model, proposing corresponding evaluation algorithms, and conducting practical practice. It is expected to provide models and algorithms that can be used for reference for the precision evaluation in the blended learning context.

II. Theoretical Basis of Precision Evaluation in Blended Learning Context

A. *Education Requirements in China*

In 2020, the State Council of China put forward General Plan for Deepening the Reform of Education Evaluation in the New Era, requiring learning evaluation to "adhere to scientific and effective, improve result evaluation, strengthen process evaluation, explore value-added evaluation, improve comprehensive evaluation, make full use of information technology, and improve the scientificity, professionalism and objectivity of

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educational evaluation". These requirements call for educators not only to focus on results evaluation, but also emphasize the combination of process evaluation and result evaluation, give full play to the role of evaluation in teaching diagnosis, and promote students' comprehensive development.

B. The Teaching Philosophy of OBE

The teaching philosophy of OBE was first put forward by Spady in 1981. It has now been regarded as the right direction to pursue excellence in education [9]. OBE emphasizes "student-centered, outcome-Based and continuous improvement". OBE focuses on four core teaching issues [9]. First, what are the learning outcomes we want students to achieve? Second, why do we want students to achieve such learning outcomes? Third, how do we effectively help students achieve these learning outcomes? Fourth, how do we know that students have achieved these learning outcomes? According to OBE, the design of learning evaluation model should take the learning outcomes that students can achieve at the end of this course as the starting point and destination.

III. Theoretical Model of Precision Evaluation in Blended Learning Context

A. Design of the Three-stage Blended Learning Process

Blended learning is a teaching method that organically integrates face-to-face off-line learning and online self-regulated learning. It combines the advantages of off-line and online learning to reduce costs and improve efficiency. Based on the above theoretical basis of precision evaluation in blended learning context, this paper designs a three-stage blended learning process (as shown in Fig. 1).

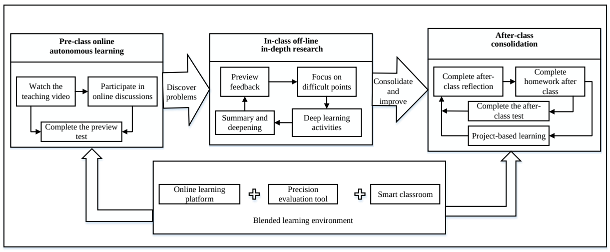

Figure 1. The three-stage blended learning process.

The learning process is divided into three stages: pre-class online autonomous learning, in-class off-line in-depth research and after-class consolidation. The difficulty of the three stages of learning activities is gradually enhanced, as well as the ability of the students to be cultivated is gradually advanced.

Pre-class online autonomous learning mainly includes watching teaching videos, participating in online discussions, and completing preview tests. In-class off-line in-depth research refers to off-line teaching activities, mainly including previewing feedback, focusing on key and difficult points, participating in deep learning activities, and summarizing and deepening. After-class consolidation mainly requires the students to complete after-class reflection, after-class homework, after-class tests, and project-based learning. In more detail, deep learning activities refer to the activities that teachers and students carry out group discussion, collaborative inquiry, case analysis, exchange and evaluation of learning results, and after-class reflection by using advanced cognitive strategies. For instance, these strategies could be analysis, synthesis, evaluation, integration, and reflection around the in-depth understanding of core knowledge, application, and solving complex problem. Project-based learning is a learning method that combines real world problems with subject knowledge and skills learning, and carries out learning in the way of project teams. It mainly includes six core links, such as problem identification, design scheme, collaborative exploration, creation of works, display of works, evaluation, and modification. Deep learning activities and project-based learning activities can effectively develop students' high-level thinking and high-level abilities, such as innovative thinking, comprehensive application and teamwork.

B. Multi-dimensional and Fine-grained Precision Evaluation Model

Based on the three-stage blended learning process, this paper constructs a multi-dimensional and fine-grained precision evaluation model (as shown in Table I). It follows the principle of "improving result evaluation, strengthening process evaluation, exploring value-added evaluation, and improving comprehensive evaluation".

TABLE I. The Multi-dimensional and Fine-grained Precision Evaluation Model

Evaluation dimension	Evaluating indicator	Evaluation content
Learning behavior	Participation (a_1)	Participation in online video learning and off-line classroom learning
	Activity (a_2)	Activity in the discussion area and off-line classroom activities
Learning attitude	Enthusias (a_3)	The degree of enthusiasm to complete online video learning, off-line classroom in-depth learning activities, after-class reflection, assignments, tests and project-based learning activities
Learning outcomes	Achievement of knowledge objectives (a_4)	Evaluate students' achievement of course knowledge objectives through assignments, tests, project-based learning and final examination
	Achievement of capability objectives (a_5)	Evaluate students' achievement of course ability objectives through assignments, tests, project-based learning and final examination
	Achievement of thinking goals (a_6)	Evaluate students' achievement of course thinking goals through assignments, tests, project-based learning and final examination
	Achievement degree of literacy objectives (a_7)	Evaluate students' achievement of course literacy goals through assignments, tests, project-based learning and final examination

The precision evaluation model reflects the dialectical unity of learning attitude, learning behavior, and learning outcomes, which is conducive to teachers' timely understanding of students' learning attitude and learning behavior, and then taking intervention measures. Learning attitude refers to the enthusiasm of students to participate in different learning activities and complete different tasks. Learning behavior refers to the degree of students' participation in various learning activities and the degree of involvement they show in the learning activities. The learning outcome is to evaluate the students' achievement of the four-dimensional curriculum objectives of knowledge, capability, thinking, and literacy.

IV. Algorithm Design of Precision Evaluation in Blended Learning Context

Based on the three-stage blended learning process and the multi-dimensional fine-grained precision evaluation model, this paper designs corresponding evaluation algorithms, including participation evaluation algorithm, activity evaluation algorithm, enthusiasm evaluation algorithm, and achievement evaluation algorithm. As shown in (1), the final evaluation result is the comprehensive score of the participation, activity, enthusiasm, and achievement evaluation results.

$$S_{\mathrm{i}} = \sum_{\mathrm{n}=1}^{7} W_n a_{in} \tag{1}$$

In (1), s_i represents the final evaluation result of the i th student. a_{in} indicates the degree of participation, activity, enthusiasm, knowledge goal achievement, ability goal achievement, thinking goal achievement, and literacy goal achievement of the i th student. w_n represents the weight and $\sum_{n=1}^{7} w_n = 1$.

A. Participation Evaluation Algorithm

Participation evaluation is composed of online video learning participation and off-line classroom learning participation. It is evaluated by collecting data such as video learning duration, video duration, and the attendance of each student in each off-line classroom.

1) Online video learning participation

The precision evaluation tool in the blended learning environment will count the cumulative duration of each student's learning duration for each online teaching video, the total duration of each online teaching video, and then calculate the completion rate with (2).

$$r_{ij} = \frac{t_{ij}}{T_j} \tag{2}$$

In (2), r_{ij} indicates the completion rate of the j th online teaching video learned by the i th student. t_{ij} represents the cumulative learning duration for the i th student to learn the j th online teaching video. T_j represents the total duration of the j th online teaching video.

The tool find out $r_j^{\max}$ (i.e. the maximum completion rate of each online teaching video among all the student in the class) and then take it as the reference standard. Eq. (3) is used to carry out the norm reference evaluation. Finally, the participation of each student in learning each online teaching video is calculated.

$$v_{ij} = \frac{r_{ij}}{r_j^{\max}} \times 100 \tag{3}$$

In (3), v_{ij} refers to the learning participation of the i th student in the j th online teaching video.

2) Participation in off-line classroom learning

The precision evaluation tool calculates the participation degree c_{ik} (i.e., the i th student in the k th off-line classroom learning) according to the attendance of the students in the offline classroom. K represents the total number of off-line classroom learning. The specific calculation method is as follows: if the student is normal attendance, then $c_{ik} = 100$. If the student is late or leaves early, $c_{ik} = 80$. If the student asks for leave, then $c_{ik} = 50$. If the student is absent from class without reason, $c_{ik} = 0$.

Finally, use (4) to calculate the participation of each student. a_{i1} refers to the participation of the i th student.

$$\mathrm{a}_{i1} = \left(\frac{\sum_{j=1}^{J} V_{ij}}{J} + \frac{\sum_{k=1}^{K} c_{ik}}{K}\right) / 2 \tag{4}$$

B. Activity Evaluation Algorithm

Activity reflects the involvement of students in the discussion area and off-line classroom learning activities. It needs to collect the number of topic posts, the number of replies, the number of times each student likes others' posts and the number of top posts posted by the student in the discussion area. Each student's score of each off-line classroom activity, the full score of each off-line classroom activity, and other data will be evaluated.

1) Online discussion activity

The precision evaluation tool counts the number of topic posts, the number of replies, the number of likes, and the number of top posts posted by each student in the discussion area. Eq. (5) is used to calculate the score of each student's participation in online discussion.

$$e_i = \sum_{l=1}^{4} \delta_l d_{il} \tag{5}$$

In (5), e_i represents the score of the i th student participating in online discussion. d_{il} indicates the number of topic posts, the number of replies, the number of likes, and number of top posts posted by the i th student in the discussion area. δ_l, represents weight and $\sum_{l=1}^{4}\delta_l = 1$.

Then, the precision evaluation tool find out $e^{\max}$ (i.e., the highest score of online discussion in the whole class) and take it as the reference standard. By using (6) to calculate the online discussion activity of each student.

$$g_i = \frac{e_i}{e^{\max}} \times 100 \tag{6}$$

In (6), g_i represents the online discussion activity of the i th student.

2) Activity of off-line classroom learning

The precision evaluation tool allows teachers to obtain data of students' participation in classroom activities (such as classroom interaction design and in-class in-depth learning activity design), and form students' classroom learning activity score. Equation (7) is adopted to calculate the activity of each student's in each off-line classroom learning.

$$u_{ik} = \frac{h_{ik}}{H_k} \times 100 \tag{7}$$

In (7), h_{ik} represents the k th off-line classroom learning activity score of the i th student. H_k represents the full score of the k th off-line classroom learning activity.

Finally, (8) is used to calculate the activity of each student.

$$a_{i2} = (g_i + \frac{\sum_{k=1}^{K} u_{ik}}{K})/2 \tag{8}$$

In (8), a_{i2} represents the activity of the i th student

C. Enthusiasm Evaluation Algorithm

The enthusiasm is evaluated from the timeliness of students' participation in different learning activities and completing various learning tasks. The more timely students participate in learning activities and complete learning tasks, the higher their enthusiasm is.

The precision evaluation tool judges whether these times are before the deadline according to the first completion time of each student's online teaching video learning, the first submission time of each classroom learning activity result, each after-class reflection, each assignment, each test, and each project-based learning result. If these times are before the deadline, the student will get "+1" points. Otherwise, the student will get "+0" points. Finally, the precision evaluation tool calculates the learning enthusiasm of each student with (9).

$$a_{i3} = \frac{f_i}{f^{\max}} \times 100 \tag{9}$$

In (9), a_{i3} represents the learning enthusiasm of the i th student. f_i is the accumulated score of the i th student's learning enthusiasm. $f^{\max}$ is the highest cumulative score of learning enthusiasm in the class.

D. Achievement Evaluation Algorithm

The achievement evaluation is based on the curriculum objectives and aims to check the students' achievement of the curriculum objectives in the four dimensions of knowledge, ability, thinking and literacy. It collects the data about assignments, tests, and project-based learning and final examination. Precision evaluation requires that when designing grading criteria for homework, test questions and project-based learning, teachers should start from the four-dimensional curriculum objectives Thus, students could gain corresponding sores after they complete each homework, test question and project-based learning activity. Based on this integral, the precision evaluation tool use (10) to calculate the degree of achievement of each student's knowledge goal, ability goal, thinking goal, and literacy goal respectively.

$$\alpha_{iv} = \frac{\sum_{m=1}^{M}(\frac{a_{imv}}{a_{mv}} \times 100)}{M} \tag{10}$$

In (10), $v \in \{4,5,6,7\}$, and a_{im4}, a_{im5}, a_{im6}, a_{im7} respectively means the i th student's knowledge objectives achievement score, the capability objectives achievement score, the thinking objectives achievement score and the literacy objectives achievement score in unit m. a_{m4}, a_{m5}, a_{m6} and a_{m7} respectively represents the full score of knowledge objectives, capability objectives, thinking objectives and literacy objectives in unit m. M represents the total number of teaching units of the course.

V. Practical Application of Precise Evaluation in Blended Learning Context

A. Practical Practice Process

1) Blended learning course and experimental samples

The course adopted was "Theory and Application of Teaching Media". This course is a teacher education course for normal majors in Beijing Union University. The experimental samples are students majoring in computer science and technology. They all have blended learning experience and the information literacy to independently carry out blended learning. The 99 students in class of 2020 were treated as the experimental group adopting the precision evaluation, while the 91 students in class of 2019 were used the traditional blended learning evaluation. All students can check their evaluation results and teachers' learning suggestions at any time during the learning process.

2) Evaluation parameters

Based on the proposed precision evaluation approach, the final evaluation results in the experimental group consists of seven indicators: participation, activity, enthusiasm, knowledge goal achievement, capability goal achievement, thinking goal achievement, and literacy goal achievement. Guided by the teaching philosophy of OBE and education requirements in China, the curriculum team and experts studied and determined that the weights of these seven parts are 20%, 15%, 5%, 20%, 20%, 10% and 10%, respectively.

According to the traditional evaluation method, the final evaluation results in the control group consists of two parts: the process performance and the final examination score. Each part accounting for 50%. Moreover, the process performance consists of attendance, homework, and test, each of which respectively account for 10%, 20% and 20%.

B. Practical Practice Effect

1) Academic performance

The average score and standard deviation of the final evaluation results of the experimental group and the control group are shown in Table II. It shows that the average score of the experimental group is significantly higher than that of the control group. Moreover, the standard deviation is significantly lower than that of the control group. It indicates that the implementation of the precision evaluation provides students with more timely and accurate learning diagnosis, which help students adjust their learning behavior and learning attitude more effectively during the learning process. As a result, students did not fall behind and have room for improvement.

TABLE II. THE AVERAGE SCORE AND STANDARD DEVIATION OF THE FINAL EVALUATION RESULT OF THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Comparison items	Experiential group	Control group
Average score	84.5	81.1
Standard deviation	6.0	9.4

2) Achievement of course objectives

As shown in Fig. 2, the achievement of the four-dimensional curriculum objectives of the course in the experimental group was higher than that in the control group. It indicates that the precision evaluation can clearly reflect the achievement of the course objectives timely. Thus, teachers can adjust teaching strategies timely during the teaching process, and ensure that the course objectives are more effectively achieved.

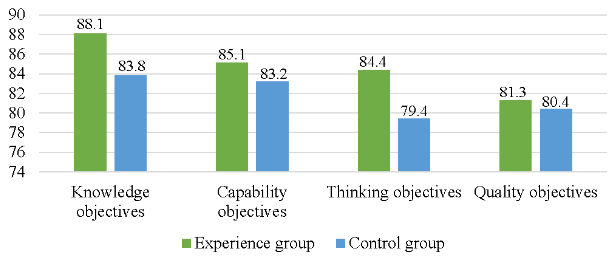

Figure 2. Comparison of the achievement of the four-dimensional course objectives between the experimental group and the control group.

C. Practical Practice Analysis

1) Reliability and validity analysis

This paper imported the score data of the seven evaluation indicators of 99 students in the experimental group into SPSS 22 for analysis. Firstly, the reliability and validity analysis was conducted. The Cronbach's Alpha coefficient is 0.798, indicating that the seven evaluation indicators have good consistency and high internal reliability. The significance value of Bartlett's sphericity test is 0.000, indicating that the data conformed to normal distribution, which was suitable for further analysis. KMO sampling suitability is 0.628, indicating that it is suitable for factor analysis. The rotated component matrix shows that the seven evaluation indicators show a validity value greater than 0.5, indicating that the seven evaluation indicators have high validity for each factor.

2) Analysis of the correlation between participation, activity and final evaluation result

This paper first draws scatter charts to explore whether there are correlations between participation and final evaluation result, and between activity and final evaluation result. The scatter chart shows that there are basically linear correlations between them. For this reason, we carry out Pearson correlation analysis on them and the results are shown in Table III. The correlation coefficient between participation and final evaluation result is 0.445 and two-tailed, indicating that there is a moderate positive correlation between them at 0.01 level. The correlation coefficient between activity and final evaluation result is 0.779 and two-tailed, indicating that there is a very significant positive correlation between them at 0.01 level. This shows that students' activity in online discussions and in-depth learning activities in off-line classes can promote their learning performance more than simply watching online teaching videos and classroom attendance. Therefore, teachers should pay more attention to the design and implementation of online interactive learning activities and off-line in-depth learning activities.

TABLE III. CORRELATION ANALYSIS OF PARTICIPATION, ACTIVITY AND FINAL EVALUATION RESULTS

	Participation	Activity	Final Evaluation Result
Participation	1	0.573**	0.445**
Activity		1	0.779**
Final Evaluation Result			1

** At 0.01 level (double tail), the correlation is significant.

3) Analysis of the correlation between enthusiasm and final evaluation results

The scatter chart shows that the relationship between enthusiasm and final evaluation result basically conforms to the linear correlation. Thus, we carried out Pearson correlation analysis on them. The calculation results indicate that the correlation coefficient between them is 0.687 and two-tailed, indicating that there is a very significant positive correlation between them at 0.01 level. This shows that the more timely students participate in various learning activities and complete various learning tasks, the better their learning results will be. It inspires us that teachers should make rules to monitor students' learning process in a timely manner to prevent students from suffering from inertia. Otherwise, students will be dragged down by laziness and eventually give up learning.

VI. Conclusion

Blended learning is becoming the "new normal" of future education. In this paper, a TsBLE approach was developed to provide students with precision evaluation and eventually improve students' learning performance. In this approach, firstly, a three-stage blended learning process was designed. Furthermore, a multi-dimensional and fine-grained blended learning precision evaluation model and corresponding evaluation algorithm were proposed. The practical practice was conducted and verified that this approach is effective and reliable. The approach can give teachers and students more accurate learning diagnosis, help teachers and students adjust learning strategies and teaching strategies in time, and improve learning performance. However, it is unavoidable that this approach requires more time and energy from teachers. In the future, we will use intelligent technology to improve the intelligent degree of the approach.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Ying Zhao designed the Three-stage Blended Learning and Evaluation (TsBLE) method and wrote this paper. Zhenzhen He design the practical practice, wrote this paper and refined it. Peng Xie and Qi Chen collected and analyzed the data. Yan Wu and Xuefeng Leng designed and developed the software tool for the precision evaluation. All authors had approved the final version.

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