The Cultivation of Students' Multiple Practical Ability Under the Multimodal Blended Teaching Mode

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Abstract—To adapt to the requirements of diversified development of modern education and the multi-modal communication between teachers and students, now high-techs and multi-modality have been introduced into the cultivation of the Multiple Practical Ability (MPA). However, existing studies on multimodal teaching generally focus on college students or high school students, few have concerned about the teaching design of practical ability cultivation under the synergy of different modalities. Therefore, to fill in this research blank, this paper took English teaching as an example to research the cultivation of MPA under the Multimodal Blended Teaching (MBT) mode. At first, this paper gave a flow chart of MBT and constructed a framework for the teaching modality system of MPA cultivation. Then, a Super-Efficiency Slacks-Based Measure (SE-SBM) model with objectively assigned combinatorial weights was established for evaluating the cultivation effect of students' MPA, and the said cultivation effect under the MBT mode was analyzed in detail. At last, the effectiveness of the proposed model was verified via experiment, and the analysis results of the differences in the MPA cultivation of students under different conditions were given.

Keywords—multiple practical ability (MPA), multimodal blended teaching (MBT), super-efficiency slacks-based measure (SE-SBM) model, English teaching, teaching mode

1 Introduction

The multimodal teaching approach adds a variety of semiotic modes - linguistic, visual, and aural meaning to the conventional single modal interactivity of texts or verbal languages of teachers, in this way, we could create richer learning experience for students, and they can use multiple sense organs for learning [1-9]. Multimodal teaching can make up for the shortcomings of conventional single modal teaching, enrich the teaching content, attract students' attention, help teachers express their emotions, and help students deepen their understanding of the teaching materials [10-15]. Now the MBT has gradually transformed from the instruction-style which centers on skill training to the cultivation of students' MPA [16-18]. To adapt to the requirements of

diversified development of modern education and the multi-modal communication between teachers and students, now high-techs and multi-modality have been introduced into cultivation of MPA, which is also the new trend for MBT reform in this era of new media [19-22]. The cultivation of MPA under the MBT mode is the hotspot and trend in MBT reform.

Information technology has brought fundamental changes to education, and information-based teaching has become an efficient teaching form. Based on the theory of multimodal discourse analysis, Guan [23] studied how to adopt multimodal teaching in vocabulary teaching of Chinese as a foreign language, stimulate students' sense organs through multi-modal forms such as words, pictures, sounds, videos and actions, so as to help students better understand and master the gramma, and trigger people's multimodality in Chinese learning. Automatic analysis of teacher-student interactions is an interesting topic in social computing, such interactions can occur online or in classrooms. Thomas [24] proposed that the multimodal behavioral signals and language use need to be measured and a model of effectiveness prediction needs to be learnt so as to characterize these interactions, and these would be conductive to characterizing the teaching skill of teachers and the level of engagement of students, besides, multiple effective teaching styles could be adopted as well. Sun [25] designed a multimodal online English teaching system and applied it to the online English teaching of the architecture major. In the research, students were divided into an experimental and a control group. The control group adopted conventional teaching, while the experimental group used the proposed system for online English learning. In view of the problem that the existing robot industry talent evaluation and training system cannot directly and effectively evaluate students' practical ability, Cai et al. [26] proposed an intelligent practical ability evaluation system that integrates software with hardware; then, the paper proposed an algorithm model combining dynamic and static algorithms to automatically score the codes submitted by students; and at last, a multidimensional comprehensive practical ability model was proposed in the texts as well. Yang and Yang [27] adopted literature review, questionnaire survey, and case analysis to analyze the problems with the training mode of full-time engineering masters. Based on elements in the practice ability of full-time engineering masters, the paper proposed a training mode for cultivating the practical ability of full-time engineering masters from aspects including training objective, curriculum setting, teaching method, practice mode, teaching staff, and guarantee system.

Existing studies on multimodal teaching generally focus on college students or high school students, few have concerned about the teaching design of practical ability cultivation under the synergy of different modalities, and they fail to comprehensively analyze the cultivation effect of students' MPA and the changes in their learning attitude. Therefore, this study combines the MBT approach with English teaching, and the main content of this paper includes: Chapter 2 gives a flow chart of MBT, and the specific steps of the designed teaching process are: class introduction, class presentation, class interaction, and class consolidation; then the paper constructs a framework for the teaching modality system of MPA cultivation. Chapter 3 builds a SE-SBM model with objectively assigned combinatorial weights for evaluating the cultivation

effect of students' MPA, and the said cultivation effect under the MBT mode was analyzed in detail. After that, the effectiveness of the proposed model is verified via experiment, and the analysis results of the differences in MPA cultivation of students under different conditions are given.

2 Process analysis of MBT

The way people interact with external environment is called a modality. A subject uses its sense organs to contact and sense material and technical media such as audios, videos, and images via visual, auditory, tactile and other perception channels, when the number of the types of media is equal to or greater than 3, then it is called multiple modalities, or multi-modal. Introducing multimodal theory into teaching means to use multiple modalities to acquire, process, and transfer teaching interaction information and teaching resource information with the help of teaching-assistant multi-media equipment, then the enriched and diversified teaching methods and modes could be adopted to mobilize students' multiple sense organs to work synergistically to realize effective internalization of the knowledge they learnt.

Figure 1 gives a flow chart of the specific steps in MBT. The designed steps of English teaching process are: class introduction, class presentation, class interaction, and class consolidation. In the class introduction link, the teaching objective is clarified and the teaching topic is determined, after that, teaching scenarios could be created and set to match with the teaching modalities effectively to realize the integration of audio-visual English teaching. In the class presentation link, attention needs to be paid to instructions in the basic knowledge level and the interestingness level to realize knowledge lecturing the relevant teaching scenarios, during implementation, attention also needs to be paid to perception channels and the complementation of material and technical media. In the classroom interaction link, the proper communication form and teaching activity type should be selected to realize the teaching activities and relevant teaching scenarios, during implementation, attention needs to be paid to utilizing perception channels and material and technical media properly. In the class consolidation link, attention needs to be paid to the targeted training of key points and difficult points in teaching and to the personalized knowledge expansion of students, so as to realize consolidation exercise and the relevant teaching scenarios, in terms of key points and difficult points, the advantages of selected perception channels and material and technical media should be highlighted.

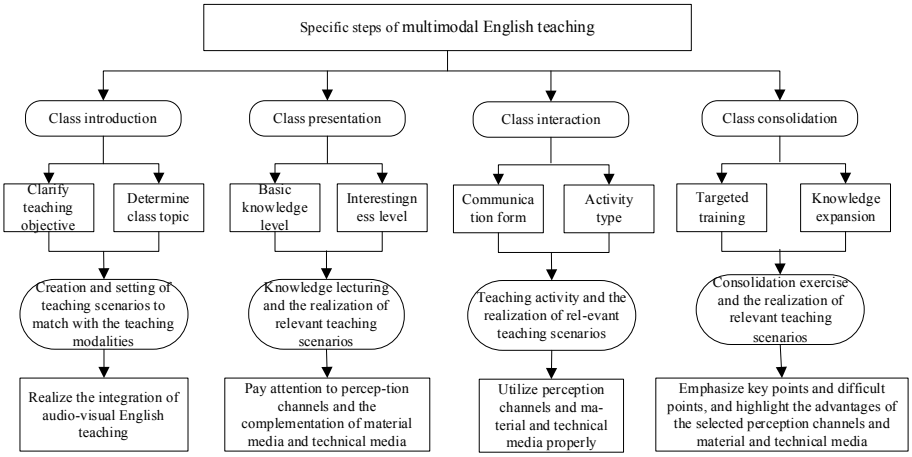

Fig. 1. Flow of MBT

Figure 2 shows the framework of the teaching modality system for cultivating students' MPA. In this framework, the teaching environment includes: facility environment, natural environment, time-space environment, sociocultural and psychological environment, class size, seat pattern, classroom atmosphere, and teacher-student relationship. The teaching procedures for the cultivation mode of students' MPA under the MBT mode include: 1) Reasonably arrange the teaching time; 2) Prepare the curriculum; 3) Plan the teaching process. The selection of IT tools for teaching includes: 1) mind map; 2) micro-course, MOOC; 3) teaching information management platform. In terms of utilizing multimodal combinations to realize integrated audio-visual teaching, the multimodal combination units include: 1) Select material and technical media such as audios, videos, and images; 2) Select perception channels such as vision, hearing, and touch.

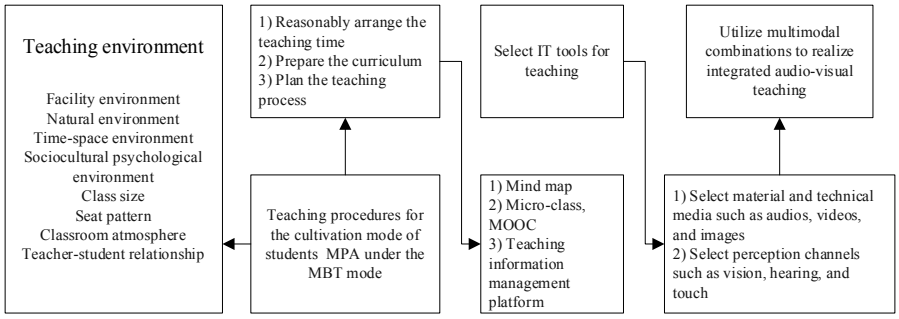

Fig. 2. Framework of the teaching modality system for cultivating students' MPA

3 Analysis of students' MPA based on Data Envelopment Analysis (DEA)

DEA compares the relative efficiency of different decision-making units (DMUs) and measures the effectiveness of each DMU completely according to objective data based on operations research methods such as mathematical programming. This paper adopted DEA to analyze the cultivation effect of students' MPA under the MBT mode.

In DEA, the C^2R model is the most commonly used one. Assuming: there are m DMUs in this model, denoted as DMU_j(j=1,2,3.....m); each DMU has n types of input indicators, corresponding to the modalities contained in the MBT mode; meanwhile each DMU has e types of output indicators, which are corresponded to the evaluation indexes of students' MPA. The input of DMU_j to the i-th indicator is represented by A_{ij}(i=1,2,3.....n), and the output of DMU_j to the i-th indicator is represented by B_{ij}(i=1,2,3.....e); v and u represent weights when the efficiency of each DMU is the highest, corresponding to the time moment the cultivation effect of students' MPA reaches the optimal, then Formula 1 gives the expression of the C^2R model:

$$\max v^T B_0 \quad S.t.\begin{cases} \dfrac{v^T B_j}{U^T A_j} \le 1, j = 1,2,...,m \\ U^T A_0^j = 1; v,u > 0 \end{cases} \tag{1}$$

The weight value obtained under the condition that the efficiency of each DMU is the highest is the most beneficial to it. Assuming: μ_j and λ_j respectively represent the weight values of the input and output indicators, then Formula 2 gives the expression of the dual model of each decision:

$$min\phi \quad S.t.\begin{cases} \sum_{j=1}^{m} A_j \mu_j = \phi A_{j_0} \\ \sum_{j=1}^{m} b_j \lambda_j = b_{j_0} \\ \mu_j \ge 0 \left(j = 1,2,...,m \right) \end{cases} \tag{2}$$

The application situation of the C^2R model is relatively simple, it is only suitable for teaching activities in which students' MPA is steadily improved under the condition that the effects of multimodal perception channels or media are improved simultaneously, considering other situations, this paper constructed a DEA model as follows:

$$min\phi \quad S.t.\begin{cases}\sum_{j=1}^{m} a_j \mu_j = \phi a_{j_0} \\ \sum_{j=1}^{m} b_j \lambda_j = b_{j_0} \\ \sum_{j=1}^{m} \mu_j = 1 \\ \mu_j \geq 0 \left(j = 1,2,...,m \right) \end{cases} \tag{3}$$

In order to effectively overcome DEA's shortcoming in radial enlargement or reduction simultaneously, a slack variable of modality and practical ability had been introduced into the objective function of the model, and Formula 4 gives the main basic form of the new model:

$$\varepsilon = min \frac{1 - \frac{1}{n} \sum_{i=1}^{n} \frac{e_i^-}{a_{ip}}}{1 + \frac{1}{e} \sum_{i=1}^{e} \frac{e_i^+}{b_{ip}}} \quad S.t.\begin{cases} a_0 = a\mu + e^- \\ b_0 = b\mu - e^+ \\ \mu \geq 0, e^- \geq 0, e^+ \geq 0 \end{cases} \tag{4}$$

Conventional DEA models can only judge whether the DMUs are valid or not, they are not able to sort each evaluation unit, so in order to solve the problems that the maximum value of effective DMUs can only be 1 and the valid DMUs couldn't be distinguished effectively, a Super-Efficiency (SE) model could be constructed as follows:

$$min\phi \quad S.t.\begin{cases}\sum_{\substack{j=1 \\ j \neq j_0}}^{m} a_j \mu_j = \phi a_{j_0} \\ \sum_{\substack{j=1 \\ j \neq j_0}}^{m} b_j \lambda_j = b_{j_0} \\ \mu_j \geq 0 \left(j = 1,2,...,m \right) \end{cases} \tag{5}$$

The difference between the SE model and conventional DEA models is that it can clearly distinguish the validity of each DMU and give evaluations after the evaluated DMUs have been removed. In order to further distinguish the validity of DMUs, this paper adopted a non-oriented SE-SBM model which can be expressed as:

$$\varepsilon = min \frac{1 - \frac{1}{n} \sum_{i=1}^{n} \frac{e_i^-}{a_{ip}}}{1 + \frac{1}{e} \sum_{i=1}^{e} \frac{e_i^+}{b_{ip}}} \tag{6}$$

Criteria for judging the validity of DEA models are:

1. If φ_0=1, and e_0^-=0, e_0^+=0; then a DMU (DMU_{j0}) can be judged to be valid; for this DMU, the output (the cultivation effect of students' MPA) obtained from the input (teaching modalities) has reached the optimal solution, and at the same time, it's judged that the organization of teaching modalities is valid and the size of teaching modalities is valid as well.
2. If φ_0=1, and $e_0^-\neq 0$ or $e_0^+\neq 0$, then the DMU (DMU_{j0}) can be judged to be weakly valid, then for this DMU, the organization and size of teaching modalities are not valid at the same time. If a certain e_0^- is greater than 0, it means that the input indicator e_0^- of the e-th type of teaching modality has not been fully utilized; if a certain e_0^+ is greater than 0, it means that there is a difference e_0^+ between the e-th type of output indicator (the cultivation effect of students' MPA) and the optimal value.
3. If φ_0<1, then the DMU (DMU_{j0}) can be judged to be invalid, the DMU is of neither the optimal teaching modality organization nor the optimal teaching modality size.

The non-oriented SE-SBM model adopted in this paper has the same problem with scientific weight calculation as conventional DEA models. In terms of the cultivation effect of students' MPA, the determination of index weights is the premise for scientific evaluation. This paper adopted an objective combinatorial weight assignment method to constrain the weight values of the constructed non-oriented SE-SBM model, this method combines the index weights obtained by the entropy weight method and by the variation coefficient method through the average weighting, and then attains the comprehensive weight.

$$\varepsilon = min \frac{1-\frac{1}{n}\sum_{i=1}^{n}\theta_i \frac{e_i^-}{a_{ip}}}{1+\frac{1}{e}\sum_{i=1}^{e}u_i \frac{e_s^+}{b_{ip}}} \quad \begin{cases} \sum\limits_{i=1,i\neq i_p}^{n}\left(a\mu - e^-\right) \le a_{ip} \\ \sum\limits_{i=1,i\neq i_p}^{e}\left(b\mu + e^+\right) \ge b_{ip} \\ \mu, e^-, e^+, \theta_i, u_i \ge 0, \sum\limits_{i=1}^{n}\theta_i = 1, \sum\limits_{i=1}^{e}u_i = 1, i = 1, 2.... \end{cases} \tag{7}$$

The evaluation indexes of the cultivation effect of students' MPA include four aspects: cognition, method, ability, and will quality. The entropy weight method can evaluate the uncertainty of evaluation indexes, the higher the uncertainty, the greater the impact of an evaluation index on the comprehensive evaluation result (the cultivation effect of students' MPA). Assuming: there are l evaluation objects and n evaluation indexes, $A=(a_{ij})_{ym}$ represents the constructed index data matrix; then, the greater the difference between evaluation index j and other index values a_{ij}, the larger the weight of this index; conversely, the smaller the difference, the smaller the weight of the index. The specific steps of the entropy weight method are:

First, calculate the weight $GV(a_{ij})$ of index value a_{ij} under the j-th evaluation index:

$$GV\left(a_{ij}\right) = \frac{a_{ij}}{\sum\limits_{i=1}^{l}a_{ij}} \tag{8}$$

The formula for calculating the entropy value r_j of the j-th index is:

$$r_j = -f\sum_{i=1}^{l} GV\left(a_{ij}\right)\ln GV\left(a_{ij}\right) \tag{9}$$

The difference factor h_j of the j-th index can be calculated by the following formula:

$$h_j = 1 - r_j \tag{10}$$

After subjected to normalization processing by Formula 11, the weight value ω_j can be obtained as:

$$\omega_j = \frac{h_j}{\sum_{j=1}^{n} h_j} \tag{11}$$

To determine the degree of influence of each evaluation index on the overall evaluation effect, this paper adopted the variation coefficient method to determine the weights of indexes through the variation of the measured values of evaluation indexes. At first, the mean and variance of each evaluation index were calculated by Formula 12:

$$A_i = \frac{1}{m}\sum_{j=1}^{m} A_{ij}; E_i = \frac{1}{m-1}\sum_{j=1}^{m}\left(A_{ij} - A_i\right)^2 \tag{12}$$

Then, the variation coefficient was calculated by Formula 13:

$$U_i = \frac{\sqrt{E_i}}{A_i} \tag{13}$$

After that, the weight of each evaluation index could be calculated:

$$\omega_i = \frac{U_i}{\sum_{i=1}^{n} U_i} \tag{14}$$

After the index weights were obtained by the entropy weight method and the variation coefficient method, the average weighting method was used to calculate the comprehensive weight of the cultivation effect of students' MPA, which was then substituted into Formula 7 to get the SE-SBM model with objectively assigned combinatorial weights for the target problem, namely the evaluation of the cultivation effect of students' MPA.

4 Experimental results and analysis

In the experiment, the weights of modalities contained in MDT and the evaluation indexes of the cultivation effect of students' MPA were solved and given in Tables 1 and 2 respectively.

In the experiment, the final comprehensive weight values were attained by the average weighting method. The comprehensive weights of input indicators (modalities contained in MDT) were 0.1581, 0.1296, 0.0484, 0.1315, 0.1449, 0.1378, 0.1343, and 0.1152, respectively; and the comprehensive weights of output indicators (cultivation effect of students' MPA) were 0.232, 0.253, 0.269, and 0.23, respectively. Then, all comprehensive weight values were brought into Formula 7 to get the SE-SBM model.

Table 1. Weight values of input indicators (modalities contained in MDT)

		Entropy weight method	Variation coefficient method	Comprehensive value
Perception channel	Vision	0.1541	0.1622	0.1581
	Hearing	0.1247	0.1345	0.1296
	Touch	0.0456	0.0512	0.0484
Material media	Audios	0.1274	0.1357	0.1315
	Videos	0.1355	0.1544	0.1449
	Images	0.1478	0.1279	0.1378
Technical media	Network	0.1367	0.1320	0.1343
	Cellphone	0.1283	0.2304	0.1152

Table 2. Weight values of output indicators (cultivation effect of students' MPA)

	Entropy weight method	Variation coefficient method	Comprehensive value
Cognition	0.239	0.225	0.232
Method	0.236	0.271	0.253
Ability	0.274	0.265	0.269
Will quality	0.241	0.219	0.23

Figure 3 shows the trend of teaching modality validity in different semesters. As can be seen from the figure, throughout the five years, overall speaking, the comprehensive validity, the validity of teaching modality organization, and the validity of teaching modality size were all in a stable state, indicating that as MBT had been implemented effectively, students' MPA was improved steadily. In semesters with a downward trend, the cultivation effect might be influenced by many aspects such as the school's teaching policy in that semester or the social and teaching environment, etc.

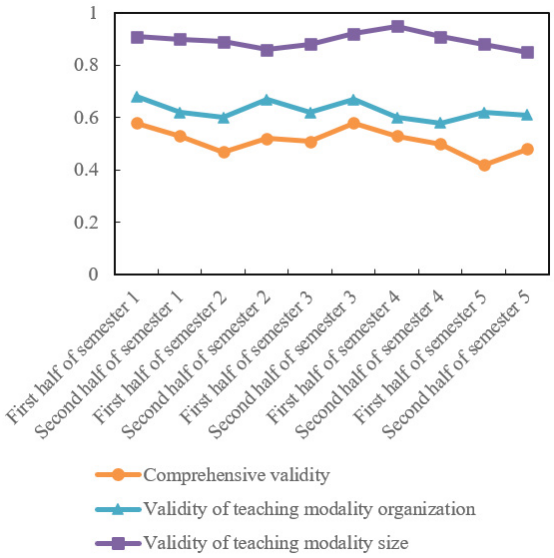

Fig. 3. Trend of teaching modality validity in different semesters

Figure 4 shows the trend of teaching modality validity of different samples. When analyzing the cultivation effect of students' MPA using the comprehensive validity, the validity of teaching modality organization, and the validity of teaching modality size, all 3 curves fluctuated greatly, especially the difference between comprehensive validity and the validity of teaching modality size was large, relatively speaking, the difference between comprehensive validity and the validity of teaching modality organization was smaller. Therefore, during the cultivation process of teaching modality organization, attention needs to be paid to the personalized learning requirements of students, and the gap in the MPA of different students should be narrowed to realize steady improvement of the overall MPA of students.

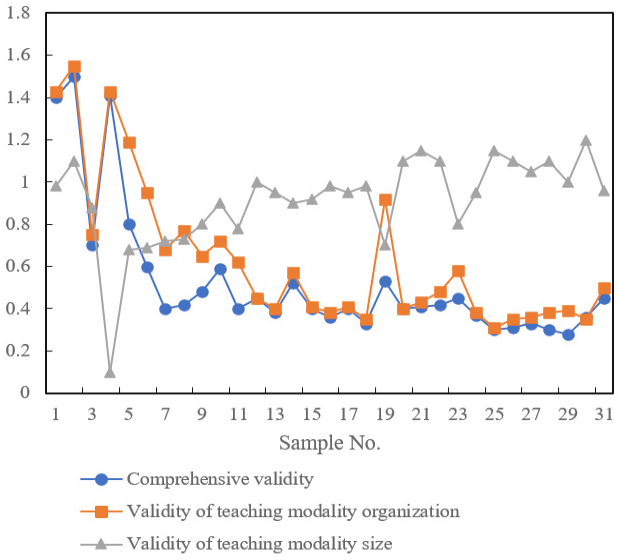

Fig. 4. Trend of teaching modality validity of different samples

Figure 5 shows the teaching modality validity of different grades. As can be known from the figure, when analyzing the data of the three grades, the comprehensive validity, the validity of teaching modality organization, and the validity of teaching modality size of the MBT classes for junior year students were all higher than those for freshman and sophomore students, and junior year students outperformed students in the other two grades in terms of adaptability, comprehension, and willpower. Thus, the effect of MBT classes for junior year students was better and more reasonable. As for freshman and sophomore students, the cultivation effect of sophomore students was better than that of freshman students, indicating that there's still a big room for the improvement of the MPA of freshman students, and it's necessary to design more reasonable MBT classes for them.

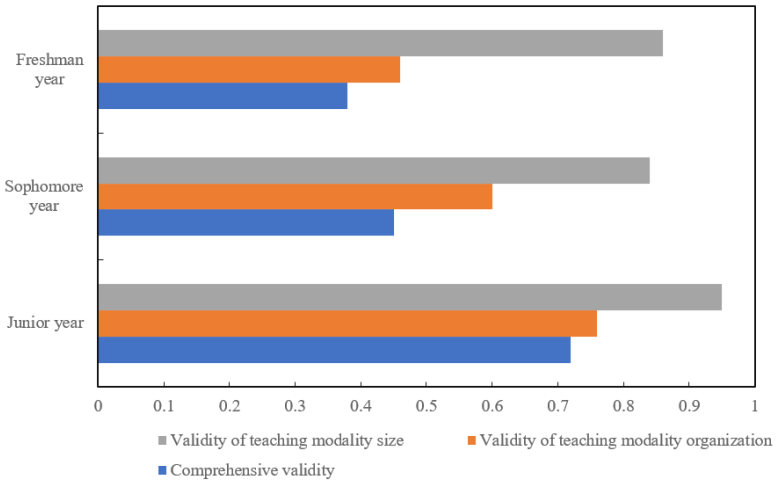

Fig. 5. Teaching modality validity of different grades

To show the change trend of teaching modality validity in different semesters more clearly, this paper plotted the curve of Malmquist index, as shown in Figure 6. Judging from the overall trend, the comprehensive validity of the classes showed an upward trend, with an average growth rate of 2.4%, indicating that the implementation of MBT had achieved certain achievements, especially in the first and second semesters, the growth rate reached 18.5%. In terms of average value, the validity of teaching modality organization and the validity of teaching modality organization advancement had increased by 3.2% and 1.8%, respectively, indicating that the teaching modality organization of MBT not only achieved great improvement in terms of class application validity, but also had some progress in terms of teaching modality organization innovation. Besides, the validity of teaching modality size and the validity of teaching modality size advancement both increased slightly, the growth rate was 1.1% and 2.1%, respectively, indicating that in recent years, regardless of material media or technical media, as long as the teaching modality size had been increased scientifically, it's conductive to the further improvement of students' MPA.

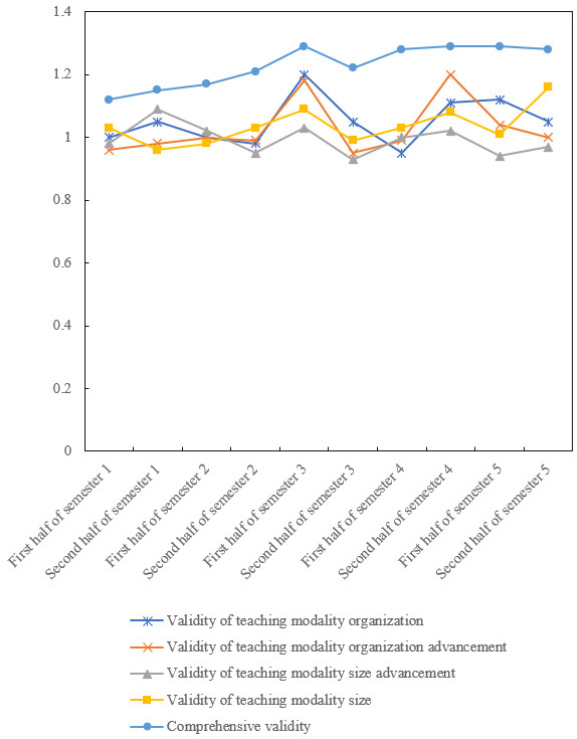

Fig. 6. Malmquist index in different semesters

5 Conclusion

This paper took English teaching as the example to study the cultivation of students' MPA under MBT mode. At first, this paper gave the flow of MBT and built a framework for the teaching modality system for cultivating students' MPA. Then, the paper constructed a SE-SBM model with objectively assigned combinatorial weights and analyzed the cultivation effect of students' MPA under MBT mode. After that, the experimental results gave the weight values of the input indicators (modalities contained in MBT) and output indicators (cultivation effect of students' MPA), and the trend of teaching modality validity of different semesters, different samples, and different grades were plotted, and the statistics of the Malmquist index in different semesters was given, showing the change trend of teaching modality validity in different semesters.

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