Implementation of Asynchronous Interactive Learning Activities in a Blended Teaching Environment and the Evaluation of its Effectiveness

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Wu Chaoqun
Foreign Languages Department, Shijiazhuang University, Shijiazhuang, China
1101607@sjzc.edu.cn

Abstract—The novel online-offline blended teaching mode is a good way to train students' comprehensive ability. The Asynchronous Interactive Learning (AIL) emphasizes students' dominant role in learning activities, which fully meets the requirements of online-offline blended teaching. However, the low effectiveness is a problem with current AIL, so this paper aims to study the implementation of AIL in a blended teaching environment and evaluate its effectiveness. At first, this paper built an Evaluation Index System (EIS) for assessing the effectiveness of AIL in the blended teaching environment, and gave the calculation method of the scores of the indexes in the proposed EIS. Then, under the condition that the authenticity of the collected index data had been fully considered, the weights of indexes were calculated based on Analytic Hierarchy Process (AHP). At last, in view of the complexity and multi-dimensionality of the factors than can affect the effectiveness of AIL, this paper evaluated the implementation effectiveness of AIL based on the fuzzy comprehensive evaluation method, and gave the analysis results of the effectiveness of AIL via experiment.

Keywords—blended teaching, Asynchronous Interactive Learning (AIL), effectiveness evaluation

1 Introduction

The class atmosphere of current online-offline blended teaching classroom in higher vocational colleges is often dull and boring since there're barely interactions between teachers and students [1-7]. The lack of good learning atmosphere, effective learning method, and timely supervision on students' extracurricular knowledge consolidation and skill training has further hurt students' learning interest and enthusiasm [8-10].

The novel online-offline blended teaching mode is a good way to train students' comprehensive ability. This new teaching mode integrates practicality with the acquired knowledge, learning interest, and individual difference of students, creating a harmonious learning environment that can effectively stimulate students' initiative [11-17]. AIL emphasizes students' dominant role in learning activities, by creating interactive and flexible teaching environment for teachers and students, it mobilizes students'

enthusiasm and initiative to the greatest extent and activates the classroom atmosphere, which can fully meet the requirements of blended teaching. Moreover, it also emphasizes the importance of student participation and the guiding role of teachers in classroom teaching; and its many advantages have made it a research focus for many scholars and researchers engaged in the field of education.

Alharbi [18] took 20 learners of English as a Foreign Language in a Saudi university as subjects to investigate the promotive effect of peer interaction and tutorial system on online asynchronous group discussion and free writing during a semester; and the study showed that, during language learning (including writing), asynchronous tools are helpful in peer interaction, and the tutorial system can promote asynchronous group discussion. E-learning platforms such as the learning management system are a good way to cultivate excellent independent learners, they can help educators, teachers, and administrators to develop and provide high-quality online courses and websites, which can meet students' requirement of accessing to information they need anytime and anywhere. Kaur and Sidhu [19] explored a few problems and challenges faced by higher educational institutions in Malaysia during their efforts of catching up with the pace of e-education, and discussed the real advantages of implementing asynchronous online learning environment for lifelong autonomous learners. DIAS is an asynchronous discussion forum software developed to provide Interaction Analysis (IA) for all possible users (individual students, groups, teachers/hosts, researchers/observers), it can be used by users together under various conditions and provide extended monitoring and interaction analysis supports that are suitable for their respective roles in different activities. Bratitsis and Dimitracopoulou [20] briefly reviewed the research results on students as users of IA tools; in another study of theirs [21], they applied such IA tools to provide support for participants of asynchronous discussion and learning activities and studied the influence of IA factors on students' self-adjustment; then, to prove their hypothesis, the authors gave the results of a few implemented research cases in which the IA tools had indeed promoted students' self-adjustment, and both quantitative and qualitative results had demonstrated that they had enhanced the overall activities and the collaboration process itself. Hewitt and Peters [22] discussed the relationship between the readability of computer conference messages and the level of student interaction during asynchronous online discussions, they performed a large-scale quantitative analysis on the activity logs of 37 graduate-level distance education courses set by the University of Toronto, and the research found that the mean reading ease and grade level scores of student messages are significantly correlated with the average number of messages written by students, the percentage of student messages replied to other messages, and average message size; and there's also a correlation between the readability of teacher information and student information, therefore, the data suggested there's a positive relationship between readability and the level of student online interactivity, and the possible explanations for these results were discussed in the paper.

Although quite a few studies have discussed AIL from the aspects of teaching status, influencing factors, teaching content, and strategies, few of them have viewed it in an online-offline blended teaching environment; moreover, most scholars generally focus on how to promote the teacher-student, and student-student online and offline interac-

tive behaviors, and an essential problem with the current AIL activities is the low implementation effectiveness. Thus, aiming at increasing the said effectiveness in a blended teaching environment, this paper took college English teaching as an example to study the implementation effectiveness of AIL in the blended teaching environment, in the hopes of providing useful evidence for AIL application in the future.

2 EIS construction

Based on an analysis of the implementation practice of AIL in the blended teaching environment, this paper adjusted the implementation strategies of AIL according to the discovered problems and the current teaching status, see Figure 1 for details. Figure 2 gives a two-tower model of AIL in the blended teaching environment, which contains three layers: the effectiveness of online AIL, the effectiveness of online-offline AIL, and the effectiveness of offline AIL.

In college English course, the key of AIL activities is to create a real language environment that offers students with opportunities to practice their English and enhance their ability to use the language to communicate. Based on the two-tower model shown in Figure 2, this paper built an EIS for assessing the implementation effectiveness of AIL activities in the blended teaching environment, see Figure 3.

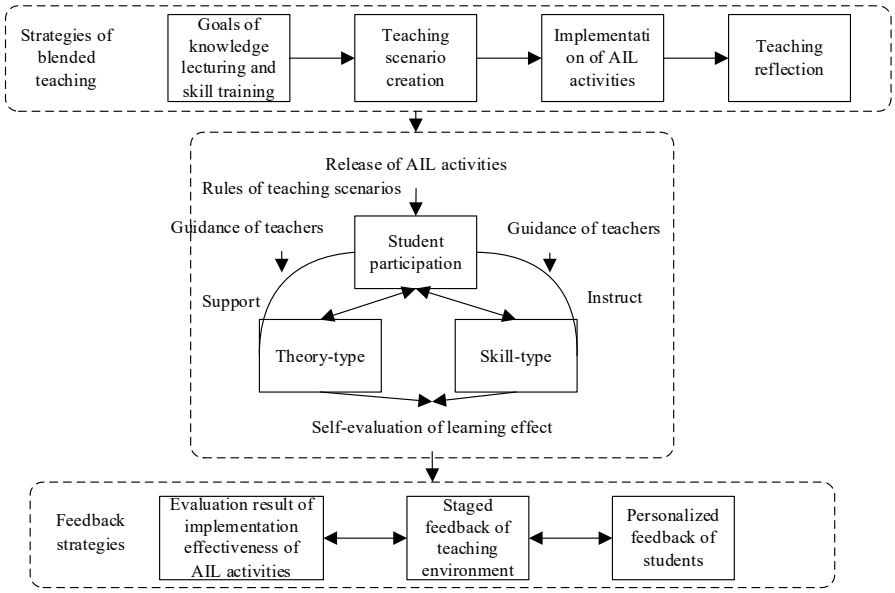

Fig. 1. Implementation strategies of AIL in a blended teaching environment

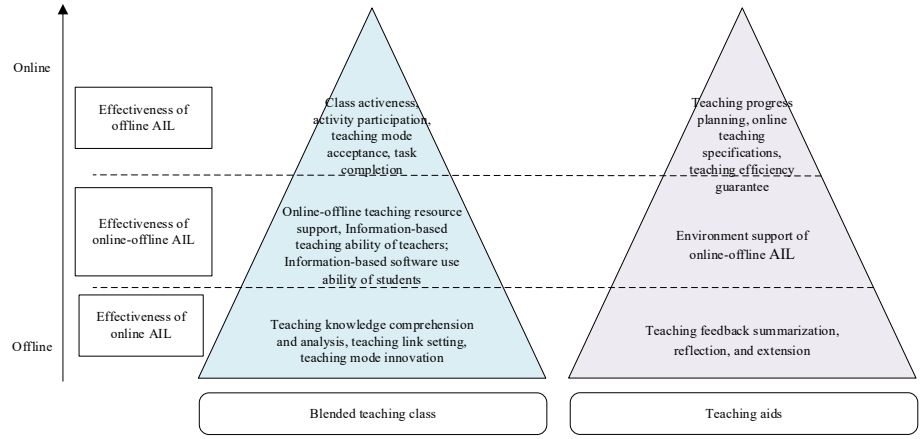

Fig. 2. Two-tower model of AIL in the blended teaching environment

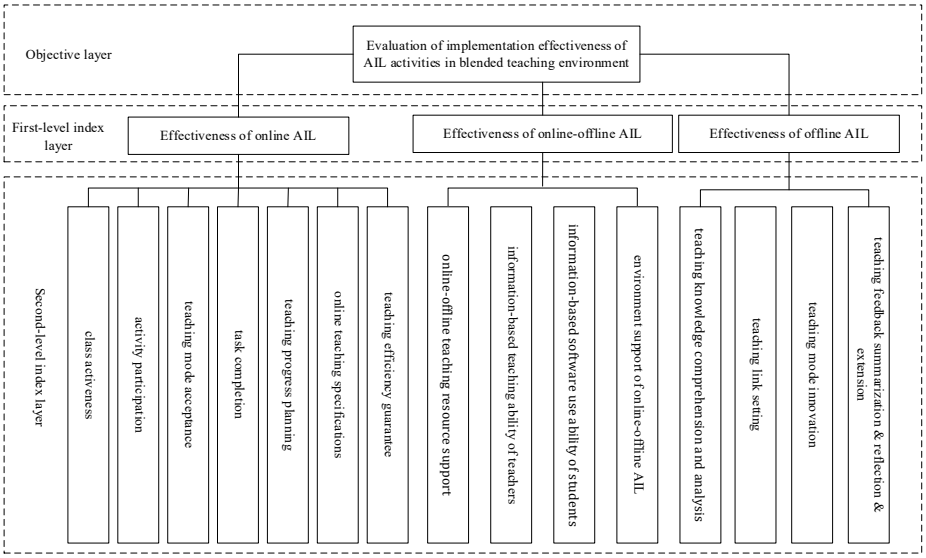

Fig. 3. EIS for assessing the implementation effectiveness of AIL activities

First layer (first-level indexes):

IE={IE_1, IE_2, IE_3}={effectiveness of online AIL, effectiveness of online-offline AIL, effectiveness of offline AIL};

Second layer (second-level indexes):

IE_1={IE_{11}, IE_{12}, IE_{13}, IE_{14}, IE_{15}, IE_{16}, IE_{17}}={class activeness, activity participation, teaching mode acceptance, task completion, teaching progress planning, online teaching specifications, teaching efficiency guarantee}

IE_2={IE_{21}, IE_{22}, IE_{23}, IE_{24}}={online-offline teaching resource support, information-based teaching ability of teachers; information-based software use ability of students, environment support of online-offline AIL}

IE_3={IE_{31}, IE_{32}, IE_{33}, IE_{34}}={teaching knowledge comprehension and analysis, teaching link setting, teaching mode innovation, teaching feedback summarization & reflection & extension}

Second-level indexes have their respective evaluation criteria, which won't be given in details in this paper.

3 Scoring method of indexes

This chapter gives the scoring method of the indexes for assessing the effectiveness of AIL activities in blended teaching environment, assuming: R_i and R_i' respectively represent the scores of indexes in the online teaching scenario and in the offline teaching scenario, both of their full scores are 100.

In the blended teaching environment, if the evaluation value of the effectiveness of theory-type AIL activities $A_i \geq A_{imax}$, then it indicates that the implementation effectiveness of AIL activities in classes dominated by theory teaching meets the standard; if $A_i \leq A_{imin}$, it means that the effectiveness degree is relatively low, and there maybe problems such as teacher-student interaction barriers; if the evaluation value of the effectiveness of skill-type AIL activities $B_i \geq B_{imax}$, then it indicates that implementation effectiveness of AIL activities in classes dominated by skill training is good; if $B_i \leq B_{imin}$, it means that for some students, the motivation attained by participating in AIL is insufficient.

In the blended teaching environment, if teachers apply AIL and students participate in it actively, then it means that the teacher-student interaction is smooth. If students' participation degree is not high, then it's necessary to evaluate the effectiveness of AIL. If the evaluation value of the effectiveness of AIL $C_i \geq C_{imax}$, then it indicates that the overall effectiveness of AIL activities is not ideal enough; if $C_i \leq C_{immin}$, then it means the overall effectiveness of AIL activities in the class is good, which can meet relevant requirements and can be applied again in the following teaching links.

Assuming: A_i represents the evaluation value of the effectiveness indexes of theory-type AIL activities in the blended teaching environment; R_{Ai} represents the score of each effectiveness index of AIL activities; R_{Qk} represents the score of theory-type AIL activities in the blended teaching environment, then there are:

$$R_{Ai} = \begin{cases} 100, \left(A_i \geq A_{imin}\right) \\ \dfrac{100 \times \left(A_i - A_{imin}\right)}{\left(A_{imax} - A_{imin}\right)}, \left(A_{imin} < A_i < A_{imax}\right) \\ 0, \left(A_i \leq A_{imin}\right) \end{cases} \tag{1}$$

$$R_{q1} = \frac{1}{m} \sum\nolimits_{i=1}^{m} R_{Ai} \tag{2}$$

Assuming: B_i represents the evaluation value of the effectiveness indexes of skill-type AIL activities in the blended teaching environment; R_{Bi} represents the score of each effectiveness index of AIL activities; R_{q2} represents the score of skill-type AIL activities in the blended teaching environment, then there are:

$$R_{Bi}=\begin{cases}100,\left(B_i \geq B_{imax}\right)\\ \dfrac{100\times\left(B_i-B_{imin}\right)}{\left(B_{imax}-B_{imin}\right)},\left(B_{imin}<B_i<B_{imax}\right)\\ 0,\left(B_i \leq B_{imin}\right)\end{cases} \tag{3}$$

$$R_{q2}=\frac{1}{m}\sum\nolimits_{i=1}^{m}R_{Bi} \tag{4}$$

Assuming: C_i represents evaluation value of the effectiveness indexes of AIL activities in the blended teaching environment; R_{ci} represents the score of effectiveness indexes of AIL activities; R_B represents the overall score of the class in the blended teaching environment; if students participate in activities actively after teachers have applied AIL, then a full score could be given to a single effectiveness index, otherwise its score could be calculated using the following formulas:

$$R_{Ci}=\begin{cases}100,\left(C_i \geq C_{imin}\right)\\ \dfrac{100\times\left(C_{imin}-C_i\right)}{\left(C_{imax}-C_{imin}\right)},\left(C_{imin}<C_i<C_{imax}\right)\\ 0,\left(C_i \geq C_{imax}\right)\end{cases} \tag{5}$$

$$R_B=\frac{1}{m}\sum\nolimits_{i=1}^{m}R_{Ci} \tag{6}$$

4 Calculation of index weight

Under the condition that the authenticity of collected index data had been fully considered, this paper calculated the weights of indexes in each layer based on AHP, the specific steps are given below.

Referring to expert opinions, a judge matrix of evaluation indexes was built, and the weights were assigned to the indexes based on the eigenvector of the judge matrix. At first, the judgment matrix was normalized using Formula 7:

$$\Pi_{ij}=\frac{d_{ij}}{\sum d_{ij}}\left(i,j=1,2,3,...,m\right) \tag{7}$$

Elements in each row of the normalized matrix were added to attain the weight vector:

$$q_i^{'} = \sum_{j=1}^{m} \Pi_{ij} \left(i, j = 1, 2, 3...m\right) \tag{8}$$

The vector attained by the above formula was normalized again to get the approximate solution:

$$q_i = \frac{q_i^{'}}{\sum_{i=1}^{m} q_i^{'}} \left(i = 1, 2, 3, ...m\right) \tag{9}$$

The approximate solution $q=(q_1,q_2,...,q_m)$ attained by Formula 9 is the solved vector. Assuming: D represents the judgment matrix; m represents the order of the matrix; $(Dq)_i$ represents the weighted value of the i-th element, then the largest eigenvalue μ_{max} of the judgment matrix can be calculated by Formula 10:

$$\mu_{max} = \sum_{i=1}^{m} \frac{\left(Dq\right)_i}{mq_i} \tag{10}$$

Formula 11 gives the calculation formula of consistency index:

$$YZ = \frac{\mu_{max} - m}{m - 1} \tag{11}$$

Formula 12 gives the calculation formula of consistency ratio:

$$YS = \frac{YZ}{SZ} \tag{12}$$

When YS is less than 0.1, it can be considered that the consistency of D is ideal; otherwise, D needs to be re-constructed.

The weights of second-level indexes relative to the weights of first-level indexes were calculated based on above steps, then, through layer combination, the weights of first-level indexes relative to the objective (the evaluation of implementation effectiveness of AIL activities) could be attained as well. Assuming: X represents the first-level index layer; Y represents the second-level index layer, there're $Y_1,Y_2,.....,Y_n$, and the corresponding weight vector is $q_1=\{y_1,y_2,\ldots,y_n\}$; Z represents the evaluation criterion layer, there are D_1, $D_2,\ldots,D_m$ indexes, and the weight vector is $q_2=\{(d_1,d_2,\ldots,d_m\}$; y_n represents the weight of second-level index Y_n to which D_i belongs; x_l represents the weight of first-level index X_l to which the second-level index Y_n belongs, then, the weight of the i-th element in the evaluation criterion layer relative to the objective (the evaluation of implementation effectiveness of AIL activities) could be calculated by the following formula:

$$Q_{Di} = x_l \times y_n \times d_i \tag{13}$$

5 Fuzzy comprehensive evaluation of the effectiveness of AIL

Since the influencing factors of the effectiveness of AIL are complex and have multiple dimensions, this paper adopted the fuzzy comprehensive evaluation method to evaluate the effectiveness of AIL activities. At first, based on the proposed EIS, the influencing factors were written as a set $V=\{v_1,v_2,\ldots,v_m\}$, wherein v_i represents the specific influencing factors, and m represents the number of evaluation indexes of the influencing factors in a same layer.

Assuming: U represents the set of comments formed by the evaluation results of AIL effectiveness attained by the evaluation system; n represents the evaluation level, there is $U=\{u_1,u_2,\ldots,u_n\}$, wherein u_j represents the j-th type of effectiveness evaluation result.

The membership degree of each evaluation index can be determined by setting several demarcation points in a continuous interval. For $V=\{v_1,v_2,\ldots,v_m\}$ and $U=\{u_1,u_2,\ldots,u_n\}$, assuming u_j and u_{j+1} represent two adjacent evaluation levels, and u_{j+1} is greater than u_j, then the membership function of v_i with respect to u_j can be expressed as:

$$s_1=\begin{cases}1, v_i < u_1\\ \dfrac{u_2-v_i}{u_2-u_1}, u_1 \le v_i < u_2\\ 0, v_i \ge u_2\end{cases} \tag{14}$$

$$s_2=\begin{cases}1-s_1, u_1 < v_i < u_2\\ \dfrac{u_3-v_i}{u_3-u_2}, u_2 \le v_i < u_3\\ 0, v_i \le u_1 \ \ or \ v_i \ge u_3\end{cases} \tag{15}$$

$$s_3=\begin{cases}1-s_2, u_2 < v_i < u_2\\ \dfrac{u_4-v_i}{u_4-u_3}, u_3 \le v_i < u_4\\ 0, v_i \le u_2 \ \ or \ v_i \ge u_4\end{cases} \tag{16}$$

$$s_j=\begin{cases}1-s_{j-1}, u_{j=i} < v_i < u_j\\ \dfrac{u_{j+1}-v_i}{u_{j+1}-u_j}, u_j \le v_i < u_{j+1}\\ 0, v_i \le u_{j-1} \ or \ v_i \ge u_{j+1}\end{cases} \tag{17}$$

Based on the s_{ij} calculated by the above formula, a membership matrix S was further constructed, and the membership degree between lower-level evaluation indexes and objective (the evaluation of implementation effectiveness of AIL activities) could be attained by multiplying the membership matrix of lower-level evaluation indexes with

the corresponding weight matrix. Assuming: R represents the membership matrix of the current layer; q represents the weight matrix of the lower layer; S represents the membership matrix of the lower layer, and "." represents the operation symbol of matrix multiplication, then there is:

$$R = Q \cdot S \tag{18}$$

Based on the principle of maximum membership degree, the final evaluation result of the effectiveness of AIL activities was the evaluation level with the largest membership degree.

6 Experimental results and AIL activities

This paper counted the time and amount of the participation of AIL activities of different students, the statistical results are shown in Figures 4 and 5. According to Figure 4, when the AIL activity is just started, the amount of student participation is less, then with the passing of time, the amount of participation increases dramatically before the activity cut-off, and it accounts for 36.8% of the total amount of participation, this indicates that there is a delay in the knowledge recognition and skill training behavior of students during the implementation of AIL, but meanwhile intervention measures such as teaching progress planning, online teaching specifications, and teaching efficiency guarantee play an incentive and constraint role in students' participation in AIL activities. Therefore, students will consciously adjust their behavior of participating in AIL in the blended teaching environment. Although most students had participated in AIL before the activity cut-off, some participated late, resulting in that the interaction time of teachers and students was not enough, so measures should be taken to further activate these late joiner students to participate in AIL.

According to Figure 5, during the implementation of AIL, students' behavior of knowledge recognition and skill training is enhanced gradually, and the amount of participation of AIL of different students tends to be stable gradually, indicating that when students are acquiring knowledge and improving their skills, the amount of participation of AIL increases.

Taking the evaluation of the effectiveness of AIL in a certain study class as an example, this paper calculated the membership degree of each index in the proposed EIS, and the calculated results showed that, for the target class, among the influencing factors of the effectiveness of AIL, 10 factors were rated as Grade-I which represents the excellent level, accounting for 2/3, as shown in Table 1.

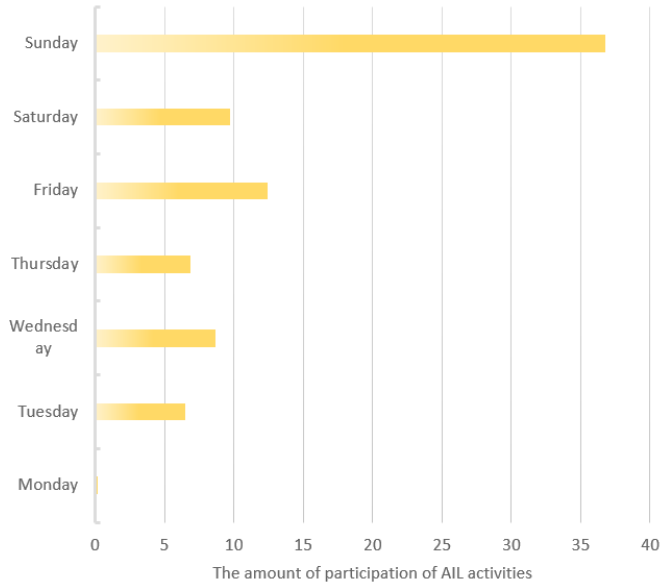

Fig. 4. The time and amount of the participation of AIL activities

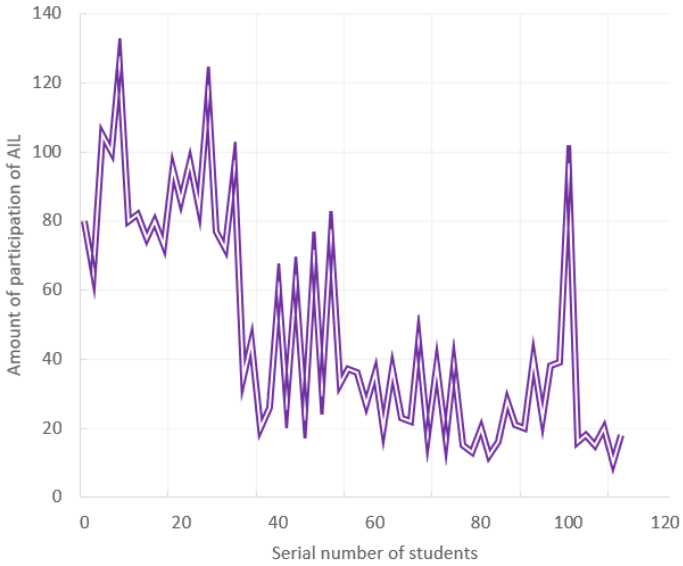

Fig. 5. Amount of participation of AIL of different students

Table 1. Membership matrix of evaluation indexes of AIL effectiveness of the study class

First-level index	Second-level index	Membership degree matrix				
		Grade-V	***Grade-IV***	***Grade-III***	***Grade-II***	***Grade-I***
IE_1	IE_{11}	0.01	0.01	0.02	0.04	0.92
	IE_{12}	0.05	0.06	0.01	0.06	0.82
	IE_{13}	0.06	0.02	0.02	0.08	0.82
	IE_{14}	0.02	0.04	0.02	0.02	0.9
	IE_{15}	0.04	0.08	0.28	0.31	0.29
	IE_{16}	0.06	0	0.12	0.43	0.39
	IE_{17}	0.01	0.02	0.31	0.24	0.42
IE_2	IE_{21}	0.01	0	0.02	0.08	0.89
	IE_{22}	0.02	0	0.01	0.09	0.88
	IE_{23}	0	0	0.04	0.06	0.9
	IE_{24}	0.01	0	0.33	0.12	0.54
IE_3	IE_{31}	0.05	0.02	0.04	0.04	0.85
	IE_{32}	0.02	0	0.04	0	0.94
	IE_{33}	0.07	0	0.01	0.03	0.89
	IE_{34}	0.03	0	0.11	0.44	0.42

According to the principle of maximum membership, the implementation effectiveness of AIL in this class was rated as Grade-I, indicating an excellent level. This study investigated the implementation effectiveness of theory-type and skill-type AIL activities in 100 study classes (Figures 6 and 7). In terms of theory-type AIL activities, among the 100 classes, 12 classes were evaluated as Grade-V, 3 classes were evaluated as Grade-IV, 12 classes were evaluated as Grade-III, 10 classes were evaluated as Grade-II, and 63 classes were evaluated as Grade-I, they respectively account for 11.54%, 3.87%, 12.11%, 9.98%, and 62.5% of the total number of classes. In terms of skill-type AIL activities, among the 100 classes, 14 classes were evaluated as Grade-V, 2 classes were evaluated as Grade-IV, 8 classes were evaluated as Grade-III, 5 classes were evaluated as Grade-II, and 71 classes were evaluated as Grade-I, they respectively account for 13.75%, 1.66%, 8.27%, 4.61%, and 71.71% of the total number of classes.

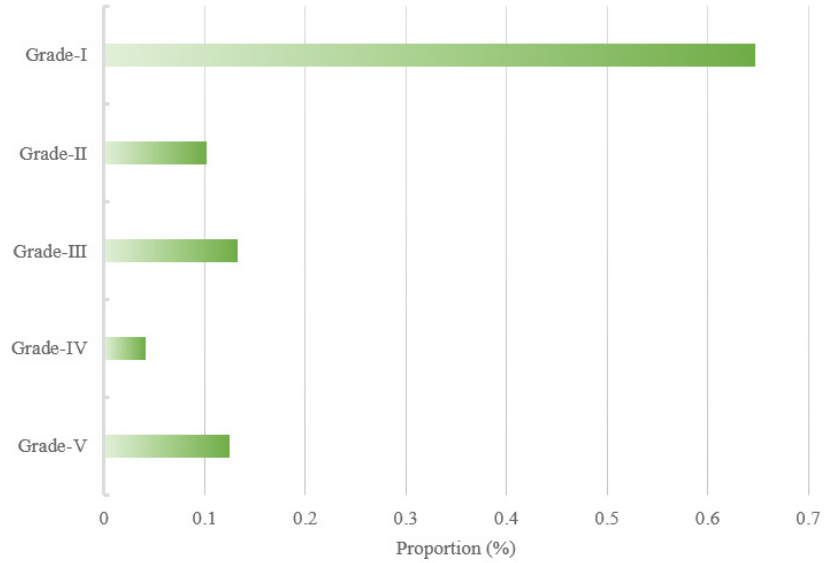

Fig. 6. Evaluation results of implementation effectiveness of theory-type AIL activities in the study class

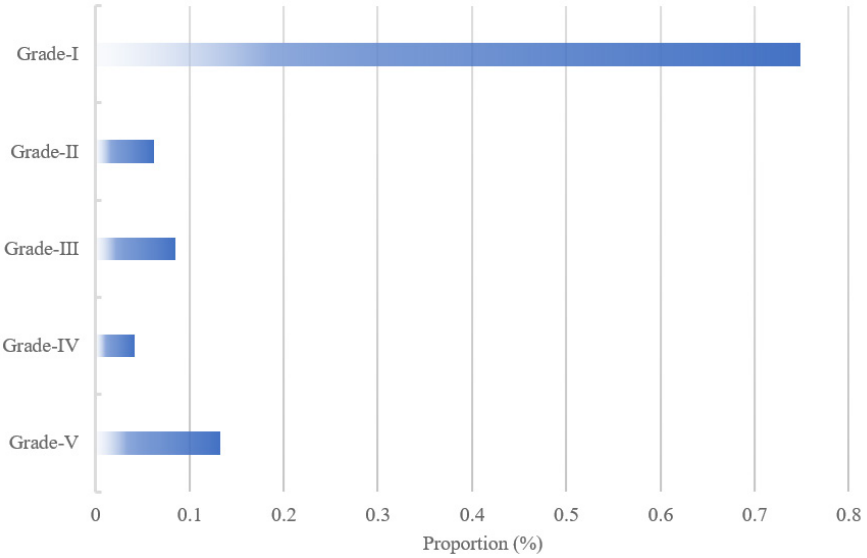

Fig. 7. Evaluation results of implementation effectiveness of skill-type AIL activities in the study class

7 Conclusion

This paper studied the evaluation of the implementation effectiveness of AIL activities in the blended teaching environment. At first, an EIS was built for assessing the said effectiveness and the scoring method of each evaluation index was given. Then, under the condition that the authenticity of collected index data had been fully considered, this paper calculated the weights of indexes in each layer based on AHP. At last, in view of the complexity and multi-dimensionality of the factors than can affect the effectiveness of AIL, this paper adopted the fuzzy comprehensive evaluation method to evaluate the effectiveness of AIL. In the experiment part, this paper counted the time and amount of the participation of AIL activities of different students, the statistical results showed that most students had participated in AIL before the activity cut-off. Then, with the evaluation of the effectiveness of AIL in a certain study class as an example, this paper calculated the membership degree of each index in the proposed EIS and gave the calculation results. At last, this paper investigated the implementation effectiveness of theory-type and skill-type AIL activities in 100 study classes and attained the evaluation results.

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9 Author

Chaoqun Wu, female, was born in October 1974. She received her master's degree in foreign linguistics and applied linguistics from Huazhong University of Science and Technology. She now works as associate professor at Shijiazhuang University. The main research directions are autonomous English learning and English teaching. She has undertaken more than ten programs at various levels, won the title of excellent individuals in cultivating students through teaching, management, and services, and received the excellent teaching award multiple times (email: 1101607@sjzc.edu.cn).

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