

# Evaluation Method of Medical Students' Public English Learning Engagement Based on Machine Learning

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**Abstract.** As one of the important groups in higher education, it is very important for medical students to pay attention to their learning path, learning state and learning effect in Public English curriculum. Based on the theory of learning engagement, this study chooses medical students' Public English learning engagement as the research object, and construct the learning engagement evaluation index system based on machine learning. This study selects 131 students majoring in clinical medicine and medical imaging of 2020 as the research objects, and conducts mixed Public English teaching practice for medical students and conducts relevant research on learning engagement on this basis. The results show that the selected medical students' behavioral engagement, cognitive engagement and emotional engagement in Public English learning are at the upper middle level as a whole. Teachers and schools should pay attention to these students' engagement in the three dimensions, especially in emotional engagement, and pay special attention to students' learning emotional experience.

**Keywords:** Learning engagement; Public English; Machine learning; Evaluation system

## I. Introduction

The research on learning engagement began with Tyler's "task time" in the 1930s. It is believed that the time of learning engagement is directly proportional to the learning effect [1]. Pace put forward the "quality of effort" at the end of the 20th century, believing that it is not enough to only pay attention to the length of time invested in learning, but also pay attention to the quality and quantity of learning engagement [2]. Kuh et al. proposed in 2006 that "learning engagement is the time and energy students devote to academic related educational activities, as well as students' views on the strength of school support for their academic development, which is reflected in behavior, cognition and emotion [3]. " Due to the development of online education and hybrid teaching, the virtuality, diversity and complexity of the network environment bring some challenges to the teaching process [4]. At the same time, learners' own network technology level, learning motivation, learning emotion and learning environment will also affect their engagement in the classroom. Therefore, under the guidance of the educational concept of "student-centered", it is necessary to explore the influencing factors of learners' learning engagement to improve their learning effect [5].

For the evaluation of learning engagement, questionnaires and scales are widely used tools. However,

for the evaluation of learners, most studies lag behind, that is, the evaluation of learners' learning engagement can only be realized after the end of the course, and there is no timely identification and adjustment. Based on the theory of learning engagement, this study chooses medical students' Public English learning engagement as the research object. Through collecting learners' process behavior data, this study constructs and trains behavior input evaluation model, timely makes evaluation in learners' learning process, visualizes the evaluation results, helps learners manage themselves, and makes it possible for teachers to timely intervene and provide learning support services.

As one of the important groups in higher education, it is very important for medical students to pay attention to their learning path, learning state and learning effect in Public English curriculum. Therefore, taking the mixed teaching model of Public English in medical colleges as the research background, according to the relevant theories of learning engagement, combined with quantitative and qualitative analysis, this topic explores the state of learners' engagement in English learning activities, and comprehensively reflects the real situation of learners' learning [6]. It is proposed to solve the ways for teachers to promote students' behavioral, emotional and cognitive engagement in mixed Public English teaching practice, so as to provide reference for medical students to invest more actively and efficiently in mixed Public English learning.

## II. Connotation of Learning Engagement

The term "learning engagement" comes from a survey named National Survey for Student Engagement (NSSE), conducted by Indiana University in the United States [7]. Kuhn, the main initiator of NSSE project, first put forward the concept of work engagement, which is defined as "the positive combination of employee self and role in work".

From the perspective of psychology, some scholars define learning engagement from the three dimensions of cognition, behavior and emotion. For example, Newmann defined the degree of learning engagement by "the psychological engagement and effort that students should promote in learning, understanding and mastering knowledge, skills and technology". According to this definition, learning engagement includes not only behavioral engagement, but also psychological engagement [8]. By summarizing previous studies and according to Bloom's classification of educational objectives, Fredricks believed

that learning engagement is a combination of cognitive engagement, emotional engagement and behavioral engagement. Many other scholars have defined the concept of learning engagement, and most of them believed that behavioral engagement is the carrier of cognitive engagement and emotional engagement, while students show more engagement in behavior and cognition in the learning process [9].

Through combing and summarizing the definition of learning engagement by scholars, it is generally believed that learning engagement in traditional learning mainly includes three dimensions: behavior, cognition and emotion [10]. In medical students' Public English curriculum, teacher-student interaction, student-student interaction and the interaction between students and learning resources have a positive impact on behavior engagement and will directly affect their academic performance [11]. Therefore, in this study, the degree of Public English learning engagement is defined as the sum of students' learning behavior in the whole learning activities, cognitive strategies used to achieve learning goals and learning emotional reactions. Generally speaking, Public English learning engagement includes behavior engagement, cognitive engagement and emotional engagement.

### III. Construction of Learning Engagement Evaluation Index System Based on Machine Learning

#### A. Evaluation Index System Construction

The evaluation index system of Public English learning engagement should fully consider learners' learning status. By summarizing and analyzing the literature and theoretical basis of learning engagement, determine the dimensions and index system of Public English learning engagement at all levels, and sort out the corresponding data collection items at all levels as much as possible. When constructing the Public English learning engagement evaluation dimension, it is necessary to select the most core and valuable indicators at all levels of dimensions, which can provide guidance for evaluating the status of College Students' learning engagement [12]. It is accurate to feed back the Public English learning engagement through the evaluation results obtained from the constructed index system.

##### (1) Behavioral engagement

Behavioral engagement is defined as the specific behavior of learners' active participation, focus on the learning process, time and effort in the Public English learning environment. Through statistical analysis of the literature, under the first-level indicator of "behavioral engagement", four second-level indicators of "participation", "persistence", "interaction", and "concentration" have been determined [13].

"Participation" refers the learner's participation in learning activities as an important manifestation of behavioral engagement, e.g. log in to the Public English learning platform, browse courses, participate in topic discussions, etc. Participation is the basic behavioral engagement of course learning, which reflects the acceptance and recognition of students' curriculum rules and

requirements, and is the basis for other behavioral engagements.

"Interaction" refers to the interaction and collaboration between students and teachers and classmates, which includes students actively communicating, discussing and collaborating with teachers and classmates in order to master knowledge and solve problems, and also includes students' engagement in establishing and maintaining good relationships with teachers and classmates. Interactive behavior can reflect students' cognitive engagement in the process of viewpoint selection, critical thinking, and collaborative knowledge construction.

"Persistence" and "concentration" are considered by many scholars as behavioral engagements that reflect the degree of hard work of students [14]. The former usually refers to the reaction and performance of students when they encounter difficulties and setbacks; the latter refers to the degree of effort the student keeps attentive. Persistence behavior reflects students' efforts and emotional management to achieve learning goals, and reflects students' persistence to goals and desire for success. Concentration behaviors reflect the students' interest in the learning content itself, and also reflect the students' ability to overcome external interference. In summary, the two types of behaviors of persistence and concentration reflect the management of students' efforts and are related to the use of metacognitive strategies.

##### (2) Cognitive engagement

The definition of "cognitive engagement" in Public English learning can be divided into two categories: one is that cognitive engagement refers to students' mastery of learning content and thinking activities in the learning process; the other mainly refers to learners to achieve their own learning goals, in the process to choose suitable methods and strategies, and to monitor and adjust their entire learning process. In this paper, we define "cognitive engagement" as: learning methods, skills and cognitive strategies to monitor and adjust the whole learning activities in order to achieve learning objectives and master curriculum knowledge points efficiently in the Public English learning environment.

##### (3) Emotional engagement

Many researchers concretized emotional engagement into learners' emotional experiences such as learning interest, pleasure, boredom, belonging and so on [15]. Emotional engagement includes learners' satisfaction with learning achievement, pleasure in the learning process and self-worth in peer interaction. Combined with the review and research background, this paper defines "emotional engagement" as: learners' sense of self-efficacy in completing tasks and solving difficulties in the process of Public English learning, and the sense of self-worth embodied in dedication.

After determining "emotional engagement" as the primary index, by focusing and screening the relevant literature containing learning emotional engagement, the "emotional engagement" is limited to two secondary indexes of "interest" and "identity". In the teaching process, if the

traditional teaching methods are used to instill the theory according to the teaching materials, the classroom teaching will be boring, the students' learning interest is not high, and the students' learning enthusiasm, initiative and consciousness cannot be mobilized. Therefore, learners' interest is a very important index in emotional engagement. In addition, learners' recognition of the learning environment, majors, and teaching methods can more actively mobilize learning enthusiasm.

### B. Index System Revision

After the initial establishment of the evaluation indicators, in order to make the indicator system more comprehensive, scientific and effective, it is necessary to conduct in-depth demonstrations on the preliminary evaluation indicator system to modify and improve the indicator system. In view of this, this research uses the Delphi method to design an expert letter questionnaire based on the preliminary Public English learning engagement evaluation index system, and invites experts in related fields as the letter expert [16]. Collect the scoring data and opinions of each expert through two rounds of expert letter inquiries. Revise and improve the preliminary evaluation index system through expert experience, and classify, merge and supplement all levels of dimensions and index items based on expert evaluation results, thereby making the evaluation index system more complete.

According to the general process of the Delphi method to revise the index system, after two rounds of expert consultation, according to the experts to evaluate and modify the corresponding index items under the evaluation dimension, the evaluation index system for college students' Public English learning engagement constructed in the research is finally determined. Based on the evaluation data and revision opinions of selected experts, the indicator system has been revised and improved as a whole on the basis of calculating the mean, standard deviation and coefficient of variation of each indicator item. It can be found that the experts still tend to agree with the evaluation index items in the study, and the mean value of each index item is relatively high and the standard deviation is also low, indicating that the experts agree that these index items are extremely important in the index system. Therefore, after revision, the evaluation index system of Public English learning engagement in this study is finally formed.

### C. Machine Learning Evaluation Model

This study builds a Public English learning behavior engagement evaluation model based on four commonly used algorithms of machine learning: logistic regression (LR), support vector machine (SVM), random forest (RF) and integrated method stacking (Stacking), and selects the optimal model to build the system through comprehensive evaluation. For the above four types of machine learning algorithm models, this paper uses the following four indicators to measure the performance of these models: accuracy (ACC), macro precision (Macro-P), macro recall (Macro-R) and comprehensive index score measurement (Weight F1). In the binary prediction experiment, the confusion matrix can be used to evaluate the effectiveness of

the model. From the confusion matrix, we can clearly see the prediction results of the model for each category, and its diagonal represents the number of correct predictions of the model. According to the confusion matrix, four important evaluation indexes of the classification prediction model can be calculated: ACC, P, R and F1 scores.

For the above four models, this paper uses the following four indicators to measure the performance of the models: accuracy (ACC), macro-precision (Macro-P), macro-recall (Macro-R) and comprehensive index weight F1 (weight F1). In the binary prediction experiment, the confusion matrix can be used to evaluate the effectiveness of the model. From the confusion matrix, we can clearly see the prediction results of the model for each category, and its diagonal represents the number of correct predictions of the model. Suppose that there are  $n$  types of prediction targets in the model, and one of them should be predicted (use  $Q$  to represent this kind of data), then TP represents the data amount that model correctly predicts class  $Q$  data, FN represents the data amount that the model mispredicts the data of class  $Q$ , FP represents the data amount that the model incorrectly predicts the data of other classes, TN represents the data amount that the model correctly predicts other types of data. The concrete manifestation of confusion matrix is shown in Table 1.

Table 1. The concrete manifestation of confusion matrix

Confusion matrix		True value	
		Positive (Q)	Negative (N)
Estimate value	Positive (Q)	TP	FP
	Negative (N)	FN	TN

According to the confusion matrix, four important evaluation indexes of the classification prediction model are calculated: ACC, P, R and F1 scores. The accuracy of class  $Q$  prediction represents the proportion of class  $Q$  data correctly predicted by the model as class  $Q$  data in all class  $Q$  data predicted by the model. The higher the accuracy, the better the model predicts this category. The specific expression of accuracy is as follow:

$$P = TP / (TP + FP) \quad (1)$$

The recall rate of  $Q$ -type prediction represents the proportion of  $Q$ -type data correctly predicted as  $Q$ -type data by the model in all real  $Q$ -type data. The higher the recall rate, the better the prediction effect of this category. The specific expression of recall rate is as follow:

$$R = TP / (TP + FN) \quad (2)$$

The F1 score of class  $Q$  prediction represents the accuracy of class  $Q$  prediction and the weighted average value of class  $Q$  prediction. The higher the F1 score, the better the model predicts this category. The specific expression of F1 is as follow:

$$F1 = 2PR / (P + R) \quad (3)$$

The accuracy of the model represents the proportion of all correctly predicted data in all data samples. Accuracy is expressed as follow:

$$ACC = (TP + TN) / (TP + TN + FP + FN) \quad (4)$$

In the multi classification task, because the confusion matrix generated is not unique, macro or micro average is needed to evaluate the performance of the model. In order to solve the problem that macro cannot measure the sample equilibrium, the following formula should be used to correct when measuring the overall effect of the model:

$$MacroP = \frac{\sum_{i=1}^L Precision_i}{|L|} \quad (5)$$

$$MacroP = \frac{\sum_{i=1}^L TP}{\sum_{i=1}^L TP + \sum_{i=1}^L FN} \quad (6)$$

$$Weighted F1 = \frac{2 \cdot Precision(weighted) \cdot Recall(weighted)}{Precision(weighted) + Recall(weighted)} \quad (7)$$

Based on the characteristics of three classifications and uneven samples after clustering, and the study found that the low engagement was mainly in time, macro average macro was used to judge the effect of the model. The index scores of each model are shown in Figure 1 ~ Figure 4.

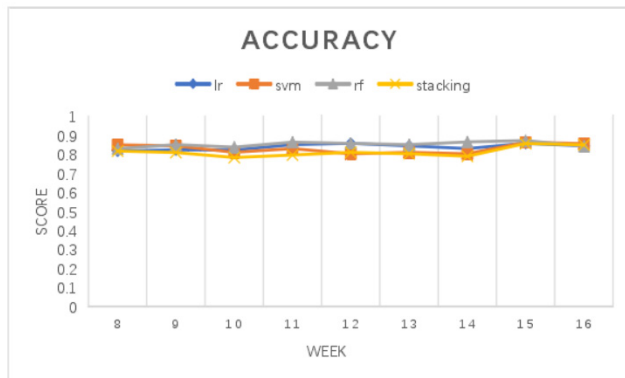


Figure 1. ACC score of each model

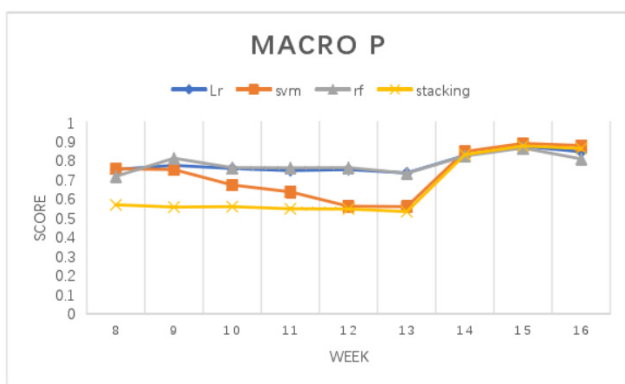


Figure 2. Macro-P score of each model

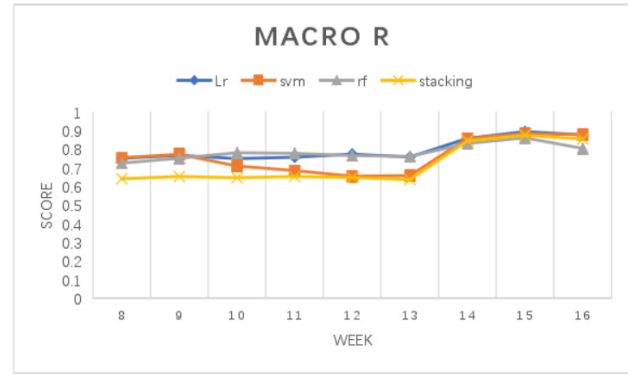


Figure 3. Macro-R score of each model

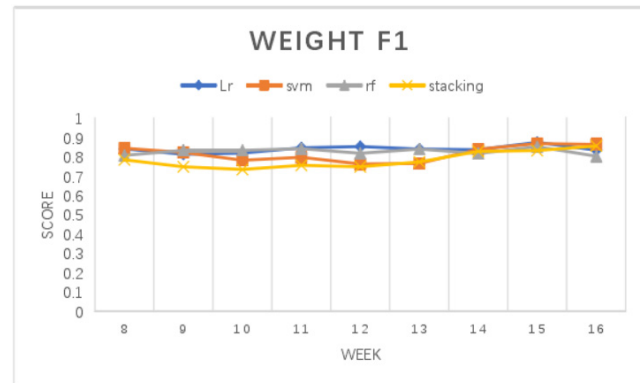


Figure 4. Weight F1 score of each model

Through the comparison of four types of models, it can be seen that the prediction accuracy of the model is maintained at about 83%. Overall model performance: RF > LR > SVM > stacking, therefore, based on the random forest model, this paper constructs a Public English learning engagement evaluation system to show the prediction results to teachers and learners more intuitively.

#### IV. Investigation and Evaluation of Medical Students' Public English Learning Engagement

##### A. Research Object

This study selects students majoring in clinical medicine and medical imaging of 2020 as the research objects, and conducts mixed Public English teaching practice for medical students and conducts relevant research on learning engagement on this basis. In order to investigate the Public English learning engagement of medical students, this study distributed a Public English learning engagement questionnaire to 131 Public English learners majoring in medicine. The 131 respondents were randomly selected from different grades. The sample characteristics of the respondents are shown in Table 2.

Table 2. Sample characteristics of the respondents

Sample	Freshman	Sophomore	Junior	Senior	Total
Male	24	16	18	19	77
Female	17	11	15	11	54
Total	41	27	33	30	131

Among the subjects, the approximate distribution of the sample's academic performance in the class is shown in Table 3.

Table 3. Subject score distribution of the sample

	A (Top 20%)	B (Top 20%~50%)	C (Top 50%~80%)	D (Last 20%)	Total
Number	29	46	37	19	131

### B. Algorithm Flow

The survey data statistics and analysis process of this study is shown in Figure 5. Firstly, the researchers put the survey data of medical students' Public English learning engagement into the computer, which are described and statistically analyzed; secondly, the differences between demographic variables and various dimensions are analyzed, and multiple post analysis is carried out for multiple groups of data variables with significant differences; finally, organize the data and describe the analysis results.

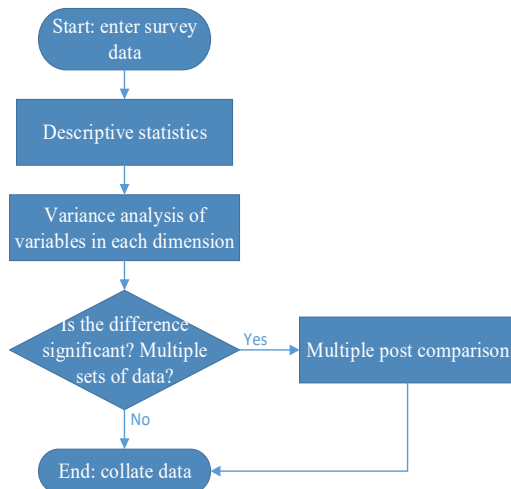


Figure 5. Survey data statistics and analysis process

### C. Research Results

The research tools of College Students' learning engagement are generally "ternary structure". Based on

Kuhn's learning engagement theory, the researcher extracted the factors required for compiling the questionnaire from the more authoritative CSEQ, NSSE English 2015, NSSE China 2014, UWES-S and other questionnaires to form a draft questionnaire. The options in the questionnaire are divided into five levels: fully compliant, mostly compliant, relatively compliant, occasionally compliant and totally non-compliant, which scores range from 5 to 1.

Based on the data, this paper makes a descriptive analysis of Public English learners' learning engagement from three aspects: behavioral engagement, emotional engagement and cognitive engagement. Descriptive statistics are made on medical students' Public English learning engagement in order to understand the overall situation of their Public English learning engagement. The method is to calculate the average value of each dimension of Public English learning engagement by using SPSSAU. The research results are shown in Table 4.

Table 4. Descriptive analysis of each dimension of Public English learning engagement

Item	Sample	Minimum	Maximum	Average	Standard deviation
Behavioral engagement	131	2.53	4.79	3.74	0.61
Cognitive engagement	131	1.78	4.78	3.62	0.70
Emotional engagement	131	1.67	5.05	3.48	0.74

As can be seen from the above table, in general, medical students' Public English learning engagement is at a medium level. Among them, the degree of behavioral engagement is the highest, followed by cognitive engagement, and the lowest is emotional engagement.

#### (1) Statistics of behavioral engagement

To make statistics on the feedback of behavioral engagement questionnaire of medical students' Public English learning, the survey results are shown in Table 5.

Table 5. Survey results of Public English learning behavior engagement

First level indicator	Second level indicator	Fully compliant	Mostly compliant	Relatively compliant	Occasionally compliant	Totally non compliant	Total
Behavioral engagement	Participation	36	45	32	12	6	3.71
	Persistence	33	48	34	13	3	3.73
	Interaction	40	46	32	9	4	3.83
	Concentration	34	42	40	11	4	3.69
	Total	-	-	-	-	-	3.74

It can be seen from the table that, the average score of behavioral engagement is 3.74. In terms of "participation", "persistence", "interaction", and "concentration", there is 27.48%, 25.19%, 30.53% and 25.95% of respondent have chosen "fully compliant", respectively.

#### (2) Statistics of cognitive engagement

To make statistics on the feedback of cognitive engagement questionnaire of medical students' Public English learning, the survey results are shown in Table 6.

Table 6. Survey results of Public English learning cognitive engagement

First level indicator	Second level indicator	Fully compliant	Mostly compliant	Relatively compliant	Occasionally compliant	Totally non compliant	Total
Cognitive engagement	Metacognitive strategy	30	48	29	16	8	3.58
	Resource management strategy	32	44	37	14	4	3.66
	Total	-	-	-	-	-	3.62

### (3) Statistics of emotional engagement

To make statistics on the feedback of emotional

engagement questionnaire of medical students' Public English learning, the survey results are shown in Table 7.

Table 7. Survey results of Public English learning emotional engagement

First level indicator	Second level indicator	fully compliant	mostly compliant	relatively compliant	occasionally compliant	totally non compliant	Total
Emotional engagement	Interest	27	42	31	20	11	3.41
	Identity	32	38	37	18	6	3.55
	Total	-	-	-	-	-	3.48

## V. Conclusion

The research goal of this paper is to construct a Public English learning engagement evaluation model by using machine learning, to explore the Public English learning engagement of medical students and explore the factors that may affect their learning engagement. This study selects 131 students majoring in clinical medicine and medical imaging of 2020 as the research objects, and conducts mixed Public English teaching practice for medical students and conducts relevant research on learning engagement on this basis.

The results show that the selected medical students' behavioral engagement, cognitive engagement and emotional engagement in Public English learning are at the upper middle level as a whole. The score of behavioral engagement is the highest, while the score of emotional engagement is the lowest. Teachers and schools should pay attention to these students' engagement in the three dimensions, especially in emotional engagement, and pay special attention to students' learning emotional experience.

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